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EVALUATION OF STORM SANDBY TANKS, COLUMBUS, OHIO

C. T. Lindblom

Dodson, Kinney and Lindblom
Columbus, Ohio

March 1971

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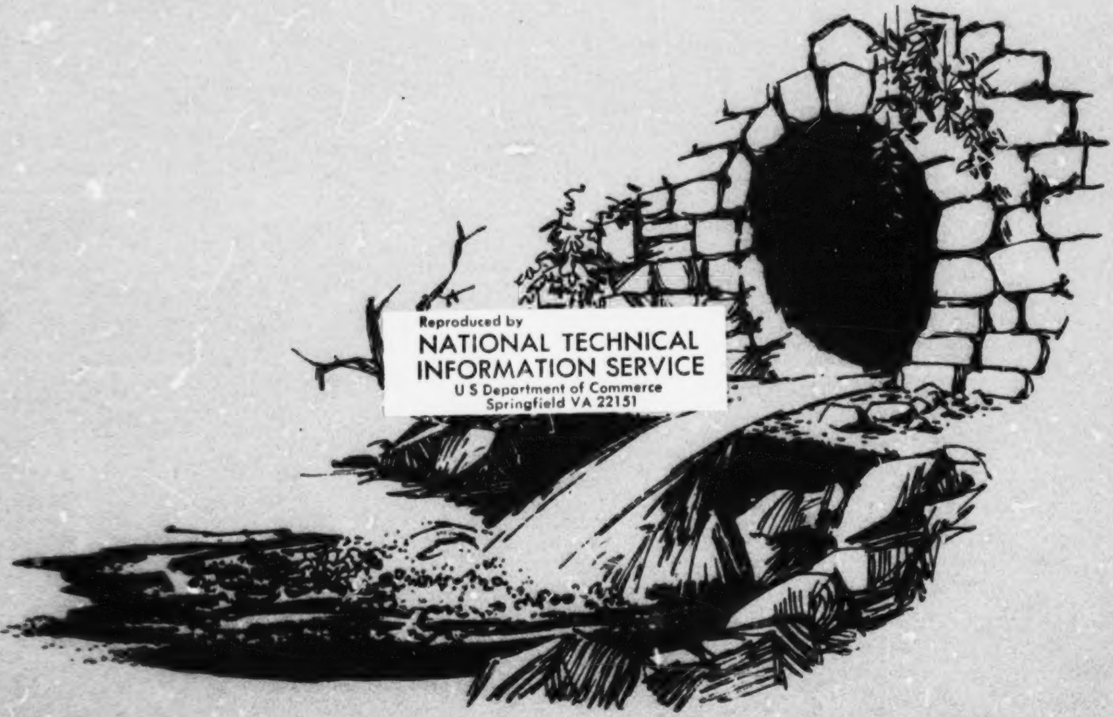

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27 **Abstract**

The operation of three storm standby tanks contiguous to an intercepting sewer which serves both combined sewers and sanitary sewers was investigated to determine the effectiveness of the tanks in improving the quality of the wastewater prior to its discharge into the river. Based on influent and effluent sampling data collected during the study period, storm standby tank facilities reduce significantly concentration of solids and B.O.D. in the wastewater in storm runoff periods. The extent of reduction is dependent to a major degree on the detention time of flow passing through the tanks. Improvement of dissolved oxygen resulting from passage of wastewater through the tanks is very substantial, especially during periods when the dissolved oxygen content of the influent is low. // Since improvement in water quality of effluent from the tanks would normally occur when volume of flow in the receiving river is above average and when its quality can be expected to be reasonably good, it is concluded that the tanks would contribute to pollution abatement only to a minor degree. However, some benefits would result from the reduced load applied to the stream, even at a time when the river could handle such load. (Lindblom, DKL)

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Evaluation of Storm Standby Tanks

Columbus, Ohio

ENVIRONMENTAL PROTECTION AGENCY
WATER QUALITY OFFICE

by

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Columbus, Ohio 43215

Program No. 11020 FAL

March 1971

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This report has been reviewed by the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

The Whittier Street Storm Standby Tanks, completed in 1932, were designed to provide partial treatment to waste water from combined sewage flows. By 1965 complaints from nearby residents about odor resulting from accumulation and removal of sludge in the tanks became numerous. To overcome this problem, the City modified the tanks in 1967 and 1968. The main modifications consisted of moving scrapers and sludge pumps to carry sludge from sumps in the tanks to the O.S.I.S. downstream of the Whittier Street Plant.

Samples of influent and effluent were obtained, and laboratory tests made for twenty-four (24) storm periods consisting of 67 composite samples between May 1968 and June 1969, to evaluate the effectiveness of the modified storm standby tanks.

Reductions in concentrations of total suspended solids from 15 to 45 percent can be expected with the detention time being from 20 to 180 minutes. The expected effluent concentrations range from 50 to 230 mg/l.

Similar reductions can be expected for settleable solids, the ranges being from 20 to over 80 percent with the detention time being between 20 and 180 minutes. The effluent values vary from 0.3 to 1.55 ml/l.

The expected reductions in B.O.D. concentrations range from 15 to 35 percent with the detention time varying from 20 to 180 minutes. The expected effluent values are between 35 and 100 mg/l.

The expected improvement of dissolved oxygen ranges from 8 percent with an influent value of 70 percent saturation to 200 percent with an influent value of 10 percent saturation.

Inasmuch as the tanks do not operate during dry weather flow periods when stream pollution problems are greatest, they cannot be considered as making a major contribution to pollution abatement. However, the tanks do improve the quality of the storm waste water passing through the tanks significantly but this usually occurs when stream flows are decidedly greater than the dry weather flow and when the quality of the stream flows are not particularly bad.

As known, indirect benefits from the long term usage of the system would exist in the reduced amount of load applied to the stream, even at a time when the stream could handle such load. However, the scope of this study was not intended to evaluate this obvious benefit.

This report is submitted in fulfillment of a grant from the Federal Water Pollution Control Administration to the City of Columbus, Ohio, and was designated as Program No. 11020 FAL. The Federal Agency was later known as the Federal Water Quality Administration and the Environmental Protection Agency, Water Quality Office.

Key Words: Combined sewers, Regulator stations, Storm standby tanks, Combined wastewater quality, Sedimentation, Solids removal, B.O.D. removal, D.O. improvement.

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SECTION I

SUMMARY AND CONCLUSIONS

Summary

The present dry weather flow in the O.S.I.S. at the Whittier Street Storm Standby Tanks is about 35 MGD. Original plans called for the tanks to go into operation when the flow reached about 68 MGD. However, since a considerable combined sewage flow also enters the O.S.I.S. downstream of the Whittier Street Plant, it sometimes becomes necessary to reduce the flow in the O.S.I.S. passing the Whittier Street facility to avoid overloading the treatment plant, when the total flow at the Jackson Pike Plant is as low as 70 MGD. Utilizing the Whittier Street Tanks to the fullest extent possible is certainly preferable to dumping combined sewage flow directly into the Scioto River. During the period of the study, hourly peak flows as great as 1030 MGD occurred at the storm standby tanks and average 8-hour flows were as much as 395 MGD.

Concentrations of the waste water in the O.S.I.S. vary considerably with the great variations in flows. The magnitude of flow and the shape of the hydrograph for a storm were found to have a bearing on the concentration of influent. Therefore, analyses of the laboratory test results were divided into two groups for the solids and B.O.D. tests. Group I consisted of all samples taken in the first 8-hour period and in periods when peak and secondary peak flows occurred. All other samples made up Group II when the flows in the O.S.I.S. were receding.

Concentrations of total suspended solids, settleable solids and B.O.D. are definitely greater for Group I samples. For total solids the concentrations are greater for Group II when the flows are of lesser magnitude. The dilution of sanitary waste for Group I samples is much greater than for Group II samples but the total solids carried by the storm water for Group I samples resulting from the flushing action during the early part of the storm offsets this dilution to some extent. After the flushing action has ended the concentrations of total solids generally decreases for a short period indicating that the waste water contains a substantial amount of storm water, including some infiltration. As the flows decrease further, the concentrations of total solids generally increase considerably, but these concentrations are still less than the values pertinent to dry weather flow. The fact that the total suspended solids and settleable solids have greater concentrations in the Group I samples is due principally to the sands and similar material flushed into the combined sewers.

Investigations revealed that the dissolved oxygen content of the O.S.I.S. waste water depended as much on its temperature as the magnitude of the O.S.I.S. flow. Consequently, the dissolved oxygen samples were divided into two groups - Group A consisting of samples having temperatures below 15° C and Group B being the samples with temperatures over 15° C. The percent saturation of dissolved oxygen increases as the temperature decreases and the flow increases.

The effectiveness of the tanks in reducing the concentrations of solids and B.O.D. was not consistent for all samples tested. However, definite patterns were developed with the available data under various rates of flow in the O.S.I.S. and flow passing through the tanks.

The expected mean reductions in total suspended solids for Group I periods vary from 70 mg/l (195-125) with an O.S.I.S. flow of 80 MGD to 30 mg/l (280-250) with a flow of 400 MGD all of which is passed through the tanks. Expressed as percentages, these are reductions of 36 and 11 percent, respectively, for flows of 80 and 400 MGD. For Group II samples, reductions range from 40 mg/l for an O.S.I.S. flow of 80 MGD to 12 mg/l for a flow of 200 MGD, or 33 and 19 percent reductions, respectively.

The reductions in total solids would consist of only those reductions obtained in total suspended solids because very little if any reductions can be expected from the dissolved solids in the waste water passing through the tanks.

Settleable solids effluent concentrations which can be expected during Group I periods vary from 0.8 ml/l for an O.S.I.S. flow of 80 MGD to 1.95 ml/l for a flow of 400 MGD passing through the tanks, resulting in reductions of 63 to 17 percent, respectively. For the Group II periods the range in reductions is from 59 percent for a flow of 80 MGD to 26 percent for a flow of 200 MGD.

The reductions in B.O.D. concentrations to be expected for the Group I periods are similar to those for the total suspended solids, varying from 33 percent to 13 percent for flows of 80 MGD and 400 MGD, respectively, and have effluent concentrations from 112 to 45 mg/l. However, the reductions which can be expected for the Group II periods are within a rather narrow range - 27 to 16 percent for flow of 80 and 200 MGD, respectively. The effluent values are 77 and 40 mg/l for the two flows.

The expected improvements in dissolved oxygen in percent saturations for the Group A periods vary from 20 percent (55% - 35%) for an O.S.I.S. flow of 80 MGD to 10 percent (70% - 60%) for a flow of 200 MGD, all of which is passed through the tanks. These are improvements of approximately 55 and 15 percent, respectively, of influent values. For Group B samples, the expected improvements vary from 20 percent (30% - 10%) for an O.S.I.S. flow of 80 MGD to 15 percent (55% - 40%) for a flow of 200 MGD, or approximately 200 and 40 percent improvements, respectively. Ten samples in the 25 periods in Group B had effluent concentrations of less than 50 percent saturation of dissolved oxygen, whereas only one sample in 25 periods for Group A had an effluent concentration less than 50 percent saturation.

Greater reductions in concentrations of solids and B.O.D. for portions of the O.S.I.S. flow at the tanks could be realized by reducing the amount of the flow passing through the tanks. This can be accomplished by keeping the regulator gates open to pass at least the dry weather rate of flow (35 MGD) and/or opening the emergency gates. However, passing 35 MGD down the O.S.I.S. would result in more of the combined sewage from the west side of Columbus being dumped directly into the river to avoid overloading the Jackson Pike Plant. By-passing the flow through the emergency gates directly into the Scioto River would not be advisable except during periods when the magnitude of flow in the river is decidedly above normal to assure greater dilution of the waste water.

The traveling sludge scrapers and sludge removal pumps have enabled the tanks to operate more effectively by constantly moving the sludge to sumps and thence pumping it to the O.S.I.S. These operations have alleviated to a great extent the odor problem associated with the tanks before they were modified. Sludge accumulated to considerable depths and then was hosed out after the tanks were emptied at the end of the storm runoff. Most of the complaints about odor were received when the tanks were being cleaned to ready them for the next storm. The continuous movement of sludge to the O.S.I.S. has not overloaded the Jackson Pike Plant and has eliminated dumping large quantities of sludge into the O.S.I.S. in a short period of time.

The primary project objective of this study, namely, the determination of the effectiveness of storm standby tanks to improve the quality of waste water and thereby decrease the pollution problem of the Scioto River was attained. Substantial reductions in concentrations of solids and B.O.D. can be expected by operation of the modified standby tanks. Similarly, operation of the tanks can be expected to provide considerable improvement in the percent saturation of dissolved oxygen, particularly at times when the rates of flow in the Scioto River are low.

Based upon the analyses of data collected for the study, the following conclusions can be drawn:

1. During periods when the storm standby tanks are in operation a substantial amount of total suspended solids and settleable solids, particularly in the Group I periods, is contained in the storm water portion of the total O.S.I.S. flow.

2. The storm standby tank facilities reduce significantly the solids and B.O.D. in the waste water in storm runoff periods. The extent of reduction is dependent to a large extent on the magnitude of flow in the O.S.I.S. Furthermore, greater reduction in solids and B.O.D. can be expected when influent concentrations and temperatures are higher.

3. The improvement of dissolved oxygen resulting from passage of the waste water through the tanks is very substantial during the periods when the influent values are low.

4. Somewhat further improvement in effluent quality would be attained if the regulator gates could be opened sufficiently to pass twice the dry weather flow (70 MGD); the length of operation time would be shortened also.

5. Construction of two additional tanks as contemplated at the time of design of the original facilities (about 1930) would further improve the

quality of effluent discharging into the Scioto River by increasing detention times, and/or by decreasing the number of times and the volume of waste water passed through the emergency gates directly into the Scioto River during high intensity storms. This improvement in quality of effluent during such storms would usually be at a time when the flow in the river would be much greater than its dry weather flow and its quality significantly better than its quality during dry weather conditions. Therefore, the construction of additional storm standby tanks, probably could not be economically justified.

SECTION II

RECOMMENDATIONS

With the Jackson Pike Waste Treatment Plant limited in the volume of flow which it can handle, from the Olentangy-Scioto Intercepting Sewer upstream of the Whittier Street Storm Standby Tanks, all flow in excess of the limited volume (often 10 MGD) will have to be passed through the tanks, except in rare instances when it will be necessary to open the emergency gates to avoid overflow of the tanks. Since some reduction in concentrations of solids and B.O.D., and in improvement of dissolved oxygen is obtained even at higher rates of flow, it is recommended that all flow up to the point where overflow of the tanks would occur, be passed through the tanks.

The construction of two additional tanks considered in the original design is not recommended because of the limited benefits which would be derived therefrom.

SECTION III

INTRODUCTION

Purpose of Project

The City of Columbus is burdened with a problem which is common to a great number of growing metropolitan areas in the United States situated along rivers having watersheds of significant size. In its early days of development, waste and storm waters of Columbus were carried directly to the Olentangy and Scioto Rivers in combined sewers. Pollution of streams was not the serious and growing problem that it is today. Except during low flow periods in the Scioto River, natural recovery from pollution of the stream due to discharges from combined sewers has been attained to date within a reasonable distance downstream of the last outlet of the sewer systems.

When the first sewage treatment plant (Jackson Pike Waste Treatment Plant) to serve Columbus was completed in 1908, the construction of separate sanitary and storm sewers had already become a policy; however, it was necessary to carry the flow of most of the combined sewers to the treatment plant for economic reasons. Construction of separate sewer systems for all the area being served by combined sewers is now far more costly than it would have been at that time.

About 50 years ago, officials of the City of Columbus began to recognize that the treatment plant capacity was not adequate to handle the peak loads which occurred during periods of storm runoff and that the problem would become more serious with the continued growth of the city. Since no action had been taken by 1927, the Ohio Department of Health ordered the city "to install such works or means as may be necessary to correct and prevent pollution of the Scioto River and Alum Creek." The Olentangy River joins the Scioto River immediately upstream of the business district of the city. Alum Creek is a tributary of Big Walnut Creek whose confluence with the Scioto River is a short distance south of Franklin County.

The measures taken by the city to comply with the above order were completed in 1932 and are described fully in the American Society of Civil Engineer Transactions for 1934, Paper No. 1887, Page 1295. Briefly, the facilities pertinent to studies presented in this report which were constructed are:

1. Olentangy-Scioto Intercepting Sewer (referred to hereafter as O.S.I.S.) to intercept sewage and large volumes of storm water from combined sewers in the Intercepting Sewer District north of Whittier Street.

2. South Side Intercepting Sewer to intercept sewage and large volumes of storm water from combined sewers in the Intercepting Sewer District

south of Whittier Street and carry it to the O.S.I.S. immediately above the storm standby tanks at Whittier Street.

3. Regulator chambers to control the flow from combined sewers to the O.S.I.S. and the South Side Intercepting Sewer.

4. Storm Standby Tanks at Whittier Street to give partial treatment by sedimentation during storm periods to flows in the O.S.I.S., in excess of controlled amounts passed to the sewage treatment plant.

The Storm Standby Tanks were designed to be adequate to meet estimated 1945 conditions and with provisions for extension to be adequate for estimated 1960 conditions. The regulator stations were each designed for capacities to handle estimated flows for 1960. The average daily flow passing through the Jackson Pike Waste Treatment Plant in 1945 was 40 MGD or 11 MGD less than was estimated in Paper 1887. In 1960 the average daily flow was 82 MGD or 2 MGD more than was originally estimated for that year. Unfortunately, there were no instruments at the Whittier Street Plant to record the time and depth of flow in the O.S.I.S. Consequently, estimated flows at that location cannot be calculated. Based on watershed areas and flows at the Jackson Pike Plant, the average daily flow of the O.S.I.S. at Whittier Street was less than the design flow for 1945 and not much greater than the design flow for 1960.

No action has been taken to construct additional tanks as recommended in the original study. Since the tanks had no provision for moving the sludge in the tanks to sumps and returned to the O.S.I.S. downstream of the storm standby tanks during the storm periods, the accumulation of sludge in the tanks often became so great, particularly in the late winter and spring months, that removal was a serious problem. The equipment provided for the removal of the sludge consisted only of a standard piece of fire-fighting equipment known as a "cellar pipe" mounted on a movable carriage which ran on rails set in the wall copings. When deposits of sludge became significant, the flushing of the sludge back into the O.S.I.S. utilizing the equipment became a difficult and slow operation. It was so ineffective that complaints of offensive odors received from the south side area increased rapidly over the years and it became necessary to modify the tanks to assure removal of the sludge more promptly.

This report describes and presents the results of a Federal Water Quality Administration sponsored project to determine the effectiveness of the modified Whittier Street Storm Standby Tanks.

Scope of Project

The character of the problem confronted (determining the effectiveness of the present storm standby tanks) encompasses several separate but related investigations in the collection and evaluation of data. Beginning with the rainfall, which is the cause of the tanks going into operation, it is necessary to supplement the United States Weather Bureau precipitation gages in the area to establish the amount of rainfall required to cause storm runoff to overflow at regulator stations and go directly into the river, and to place the storm standby tanks into operation. Rainfall data are also useful, together with other data, in computing the frequency with which the tanks are utilized and thus determine whether additional tanks would be desirable. Information is also needed on the amount of flow in the O.S.I.S. at Whittier Street when the tanks are in operation, the amount of flow passing through the tanks and thence into the Scioto River, and flow which is being bypassed to the river at typical regulator stations. Such data are pertinent to analysis of results of laboratory tests made of influent and effluent samples. Consequently, water level recorders are needed for the O.S.I.S. at Whittier Street, for the storm standby tanks, and typical regulator stations.

To achieve the prime objective of the study, of course, necessitates the sampling and testing of influent and effluent at the storm standby tanks under varying conditions. Therefore, it was necessary to install the required piping and pumping equipment to carry the influent and effluent to a common point where samples could be obtained conveniently and stored properly for delivery to the laboratory. Actual sampling operations were undertaken as soon as possible after the tanks went into operation during various storm periods. Personnel of the Jackson Pike Treatment Plant advised representatives of the contractor for this study as soon as the control panel at the plant for the Whittier Street Station showed that the inlet gates to the tanks had opened.

Project Objectives

The prime objective of the study is to determine the effectiveness of the modified storm standby tanks in diminishing the pollution of the Scioto River downstream of those facilities. If the study finds that the tanks produce sufficient improvement in the quality of the waste water, further studies might be justified to ascertain the economic feasibility of the construction of an additional tank or tanks as contemplated in the original plans for the storm standby tanks. Findings of the study may be helpful to other cities seeking a solution to the same problem of having to process or bypass waste water from combined sewers during periods of storm runoff.

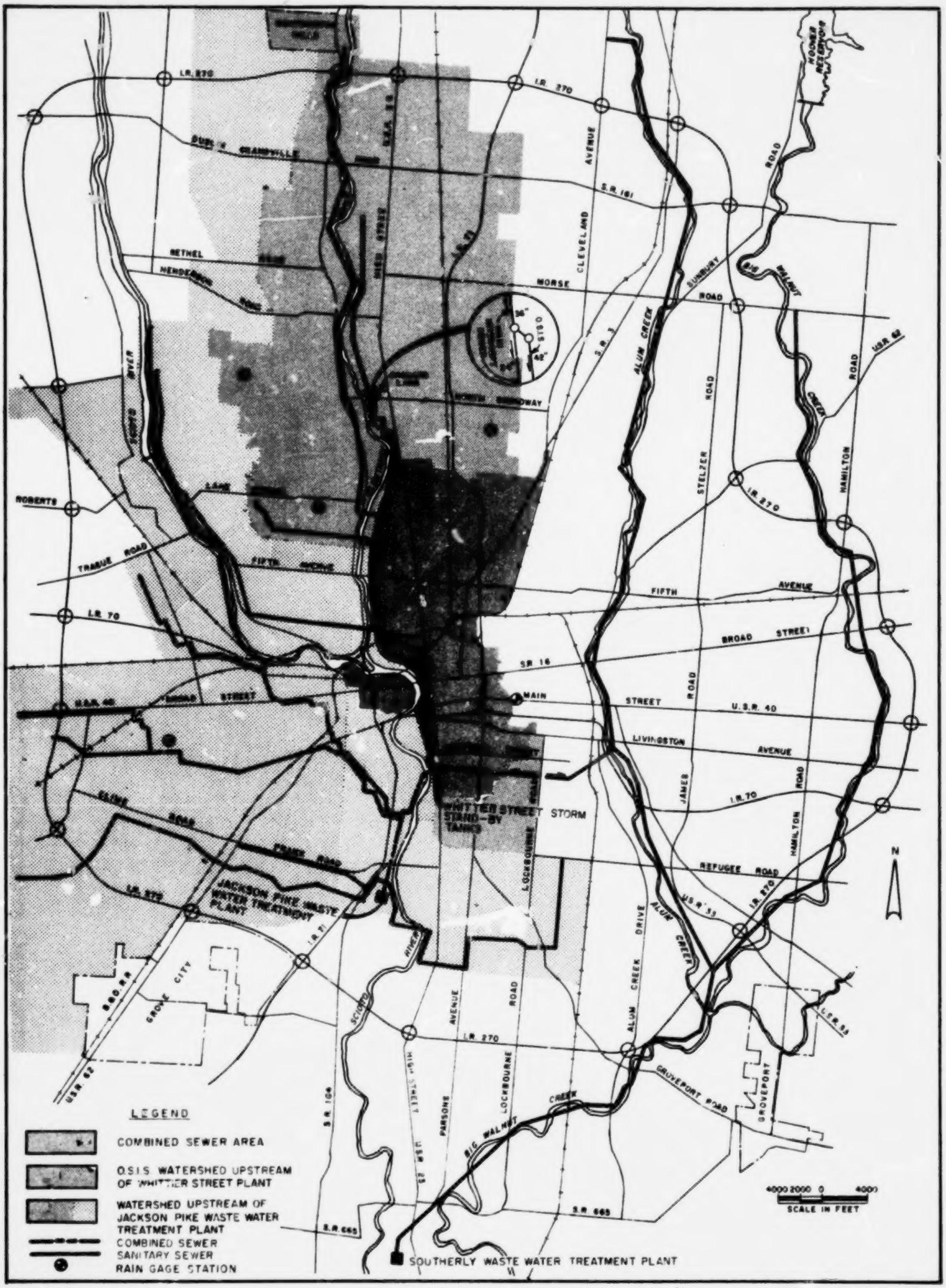


FIGURE 1 WATERSHED MAP

SECTION IV

DESCRIPTION OF EXISTING FACILITIES

Olentangy-Scioto Intercepting Sewer

The Olentangy-Scioto Intercepting Sewer (O.S.I.S.) extends from the Jackson Pike Waste Treatment Plant to Orchard Lane about nine miles north of Whittier Street Storm Standby Tanks. As shown on Figure 1, the O.S.I.S. above Whittier Street serves combined sewer areas east of the Olentangy and Scioto Rivers, and sanitary sewers in an extensive area west of the Olentangy River and north of Fifth Avenue and in a smaller area east of the Scioto River south of Whittier Street. Also, it will be noted in Figure 1 that the Main Intercepting Sewer is connected to the O.S.I.S. at its upper extremity (Orchard Lane) to permit any overload of the Main Intercepting Sewer to overflow into the O.S.I.S. The South Side Intercepting Sewer joins the O.S.I.S. just upstream of the Whittier Street Tanks. This sewer picks up the sanitary flow from one area served by separate sewers and from two areas served by combined sewers. Between the Jackson Pike Plant and the Whittier Street Tanks, the O.S.I.S. receives combined sewage from the west section of Columbus during storm periods. Although the sanitary and storm sewers are distinctly separate in most of the area, the two systems are interconnected at two locations as they approach the O.S.I.S. One interconnection is immediately west of Interstate Route 71 and about 5,000 feet south of Whittier Street and the other is at a gate chamber along the O.S.I.S. and west of the other interconnection. The design capacity of the O.S.I.S. at the tanks is 487 MGD. When the storm standby tanks were designed, it was assumed that twice the dry weather flow at Whittier Street (or 84 MGD by 1960) would be carried in the O.S.I.S., leaving 403 MGD to be passed through the tanks. Under this situation, the detention period for storm water would be about 15 minutes.

During the periods of sampling for this study, the average rate of flow for any 8-hour period in the O.S.I.S. at the tanks reached a maximum rate of 395 MGD, of which only 10 MGD was continuing in the O.S.I.S. downstream of the tanks. The flows from other trunk sewers entering the O.S.I.S. downstream of the tanks limit the flows which can be carried past the tanks. During average intensity storms much less than the design flow (84 MGD) can be carried past the tanks. The extent to which the regulator gates of the O.S.I.S. are open at Whittier Street Station, is controlled by operators at the Jackson Pike Plant who must consider the flow picked up by the O.S.I.S. between Whittier Street and the Plant. Many times during the sampling periods for this study both regulator gates were essentially closed, with only 10 MGD being carried on to the Jackson Pike Plant. At those times all remaining flows in the O.S.I.S. above Whittier Street were being passed through the tanks and emergency gates as described hereafter.

Storm Standby Tanks

The Storm Standby Tanks at Whittier Street (see Figure 2) were designed to provide partial treatment by sedimentation to storm sewage flows in excess of flows passed on to the Jackson Pike Plant. The primary function of the tanks was to remove as much heavy suspended solids and floating materials as possible from the waste water passing through the tanks prior to discharge of the effluent into the Scioto River.

The original design of the three tanks provided for six times the average dry weather flow estimated for 1945, or 204 MGD, to pass through the tanks. A detention period for this rate of flow would be 30 minutes. Two times the average dry weather flow, or 68 MGD, would be carried past the tanks in the O.S.I.S. to the Jackson Pike Plant. For estimated 1960 conditions, twice the average dry weather flow, or 84 MGD, would be discharged through the O.S.I.S. to the Jackson Pike Plant and 252 MGD would pass through the tanks with a detention period of about 24 minutes. With the modified tanks the detention periods for the estimated 1945 and 1960 conditions are 27 and 22 minutes, respectively.

Modification of the original construction was made in the latter part of 1966 and in 1967. Modifications made were all pertinent to the prompt removal of sludge from the tanks. Whereas the original construction provided a number of lateral drains running from each side to a single longitudinal drain extending from the far end of the tank to the drain gate at the O.S.I.S., the modified tanks have valleys, or troughs, running parallel to, and about one-fourth the width of the tank, from each side thereof. The valleys, in turn, slope from the endwalls of the tank to sumps located 63 feet (or about one-third the length of the tank) from the influent end. A traveling scraper in each tank moves the sludge slowly from one end to the sumps and then from the other end to the sumps. Each sump is of reverse pyramidal shape, with each side being 8 feet at the floor of the tank and 2 feet at a depth of about 4 feet below the bottom of the tank. The sludge collected in the sumps is then pumped to a collector pipe which carries it to a manhole over the Alum Creek Intercepting Sewer, east of the Control House, where it is carried to the O.S.I.S. downstream of the regulator gates.

The original construction provided for flushing the sludge out of the tanks after they have been emptied of all liquid and the inlet gates closed. The sludge left the tank by way of the lateral and longitudinal drains, and the drain gates to the O.S.I.S. upstream of the Control House. As stated early in this report, the equipment used for flushing the tanks, as originally built, consisted merely of using a "cellar pipe" and fire hose mounted on a movable carriage on the side walls of the tanks. In contrast, each modified tank has four 6-inch spray headers running the length of the tanks, one on each side wall and two, four feet apart, along the centerline of the tank.

Some of the major items indicating operating conditions at the Whittier Street Storm Standby Tanks are recorded at the Jackson Pike Treatment Plant, namely, the water levels in the O.S.I.S. immediately above and below the regulator gates, and in the outlet channel to the river immediately below the storm overflow tanks, and the depth of flow over the tank weir. Other phases of the operation are shown at the Jackson Pike Plant by indicators, or indicating lights. Indicators show the extent to which the regulator gates are opened. Lights show whether other gates are open or closed (emergency gates, storm overflow gates and shut-off gates) and whether each of the tanks is, or is not, operating.

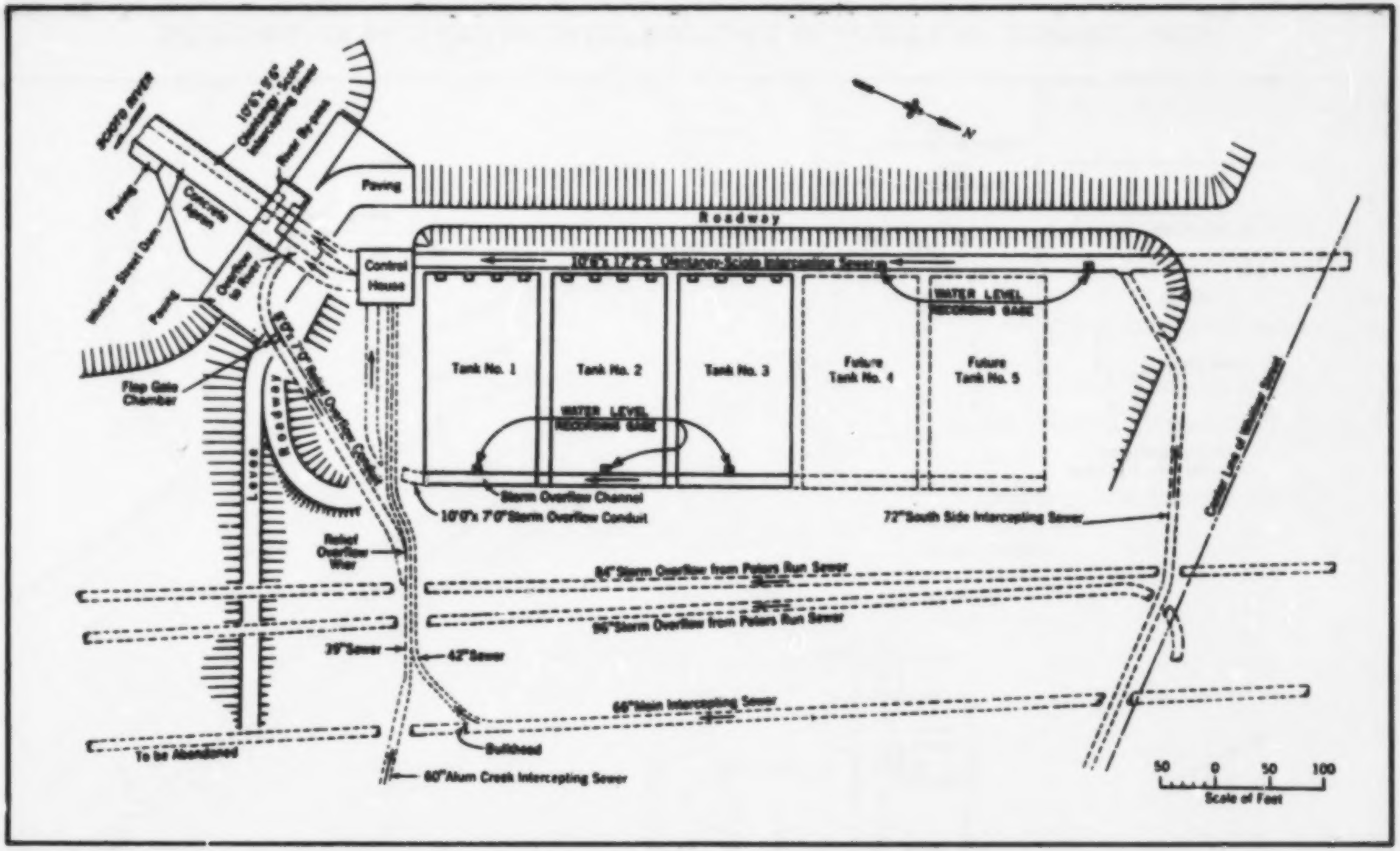

Scioto River
10'6"x 9'6" Olentangy-Scioto Intercepting Sewer
River By-pass
Paving
Concrete Apron
Whittier Street Dam
Paving
Overflow to River
Paving
Flap Gate Chamber
Control House
Roadway
10'6"x 17'2"S Olentangy-Scioto Intercepting Sewer
Tank No. 1
Tank No. 2
Tank No. 3
Future Tank No. 4
Future Tank No. 5
WATER LEVEL RECORDING GAGE
WATER LEVEL RECORDING GAGE
Storm Overflow Channel
10'0"x 7'0" Storm Overflow Conduit
8'0"x 7'0" Relief Overflow Conduit
Roadway
Levee
Relief Overflow Weir
72" South Side Intercepting Sewer
Center Line of Whittier Street
84" Storm Overflow from Peters Run Sewer
96" Storm Overflow from Peters Run Sewer
39" Sewer
42" Sewer
66" Main Intercepting Sewer
Bulkhead
To be Abandoned
60" Alum Creek Intercepting Sewer
N
50
0
50
100
Scale of Feet

FIGURE 2 SITE PLAN OF STORM STAND-BY TANK FACILITIES

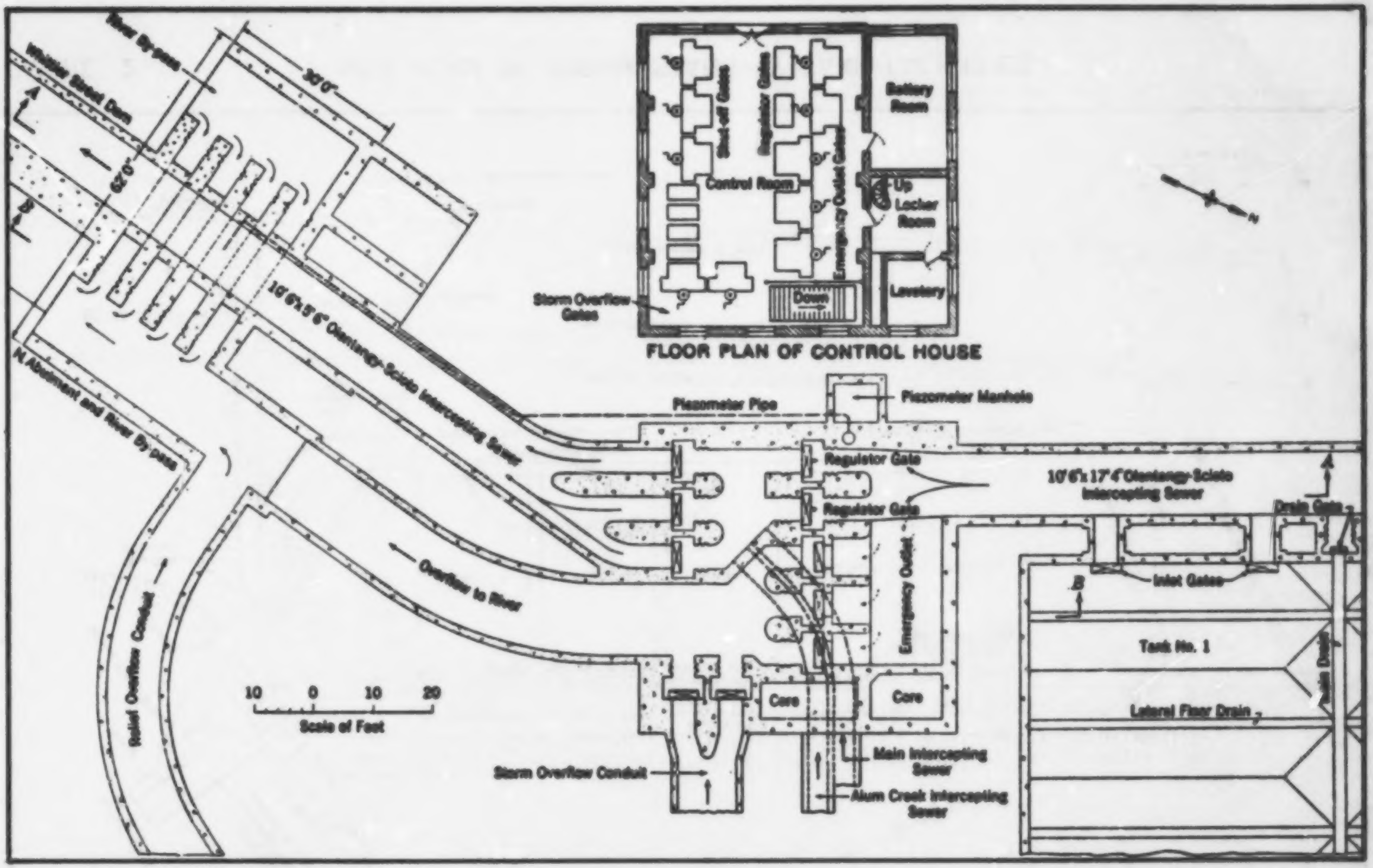


FIGURE 3 SECTIONAL PLAN THROUGH SUBSTRUCTURES IN VICINITY OF CONTROL HOUSE

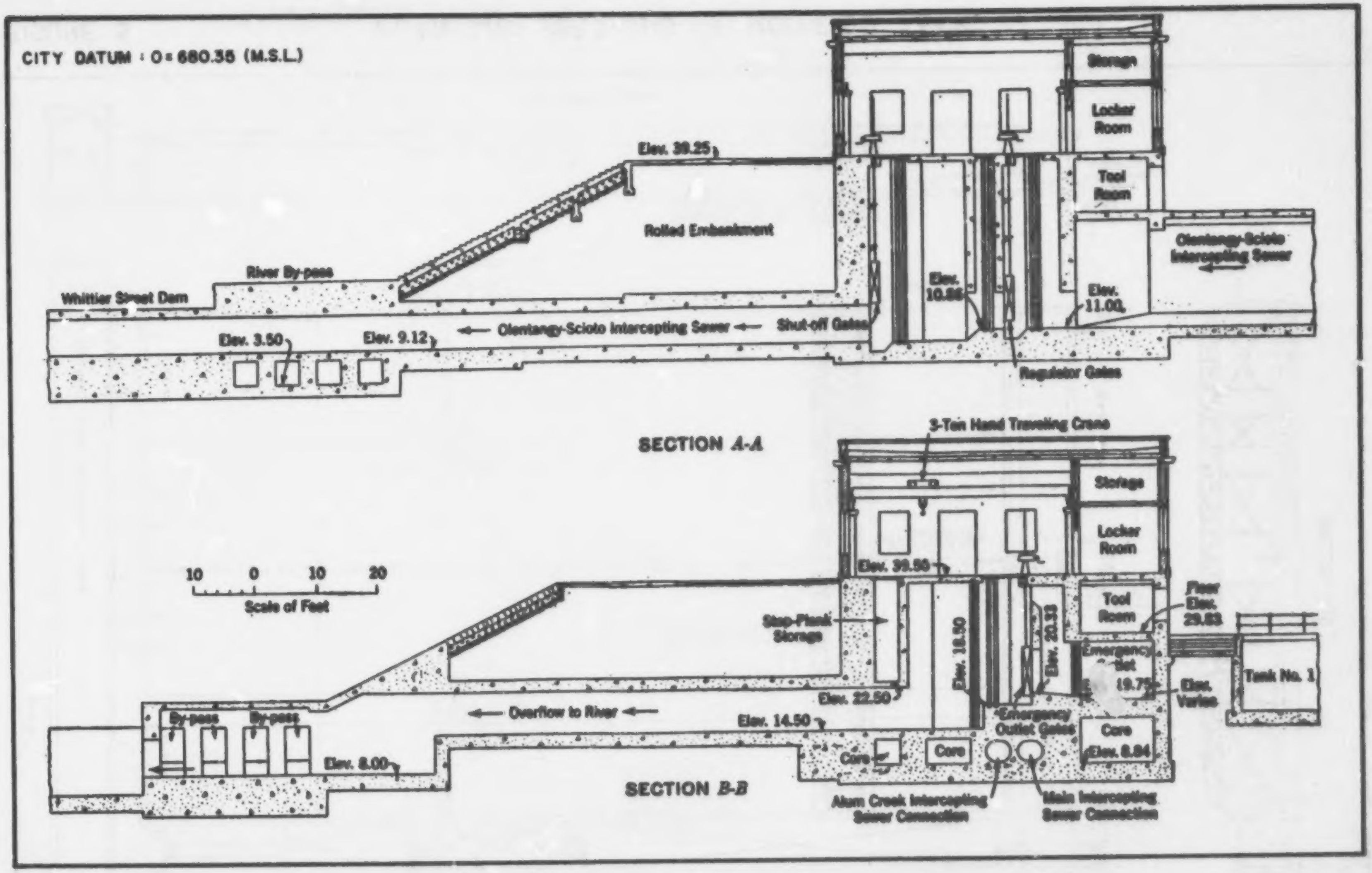


FIGURE 4 SECTIONS THROUGH CONTROL WORKS

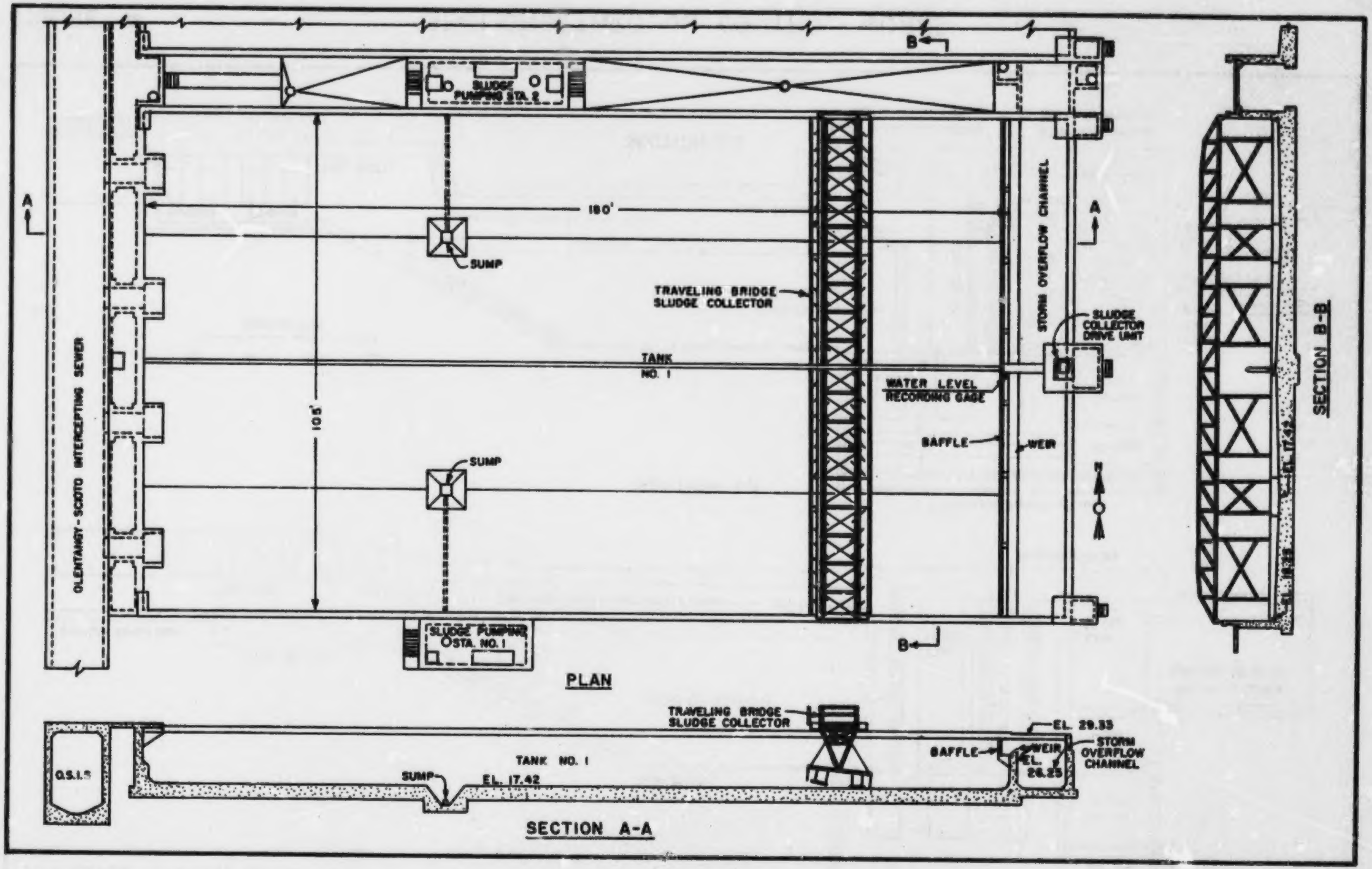


FIGURE 5 PLAN AND SECTIONS OF MODIFIED TANKS

There are two regulator gates, each 42 inches by 72 inches, in the O.S.I.S. at the Control House for the Whittier Street Storm Standby Tanks which control the volume of flow to the Jackson Pike Plant. These gates are now operated normally from the treatment plant, although they can be operated at the Whittier Street Station. Prior to modification of the tanks they operated automatically, opening and closing with the change in water level in the O.S.I.S. below the gates. These gates were operated manually at the Whittier Street Plant several times during sampling operations but were never fully opened. Another control utilized during the study was the operation of the three emergency gates, each 48 inches by 84 inches. Normally, these gates are opened only when the river stage is so high that it would cause the tanks to be inundated; and the shut-off gates, storm-overflow gates, and the inlet drain gates of the tanks are closed. The emergency gates were opened for limited periods for purposes of this study to regulate depth of flow over the tank weirs and thus control the detention period.

Operation of the Storm Standby Tanks begins when the O.S.I.S. stage reaches Elevation 707.0 feet above mean sea level (m.s.l.), or about 0.4 foot above the elevation of the tank overflow weirs, and will continue in an open position until the O.S.I.S. stage drops to Elevation 702.0 feet (m.s.l.). The invert elevation of the inlet gates is 698.85 feet (m.s.l.) and the top elevation is 702.85 feet (m.s.l.). The invert and inside top elevations of the O.S.I.S. at the tanks are 691.35 and 708.35 feet (m.s.l.), respectively. About a 0.2 inch rainfall over the combined sewer area must occur to place the storm standby tanks into operation.

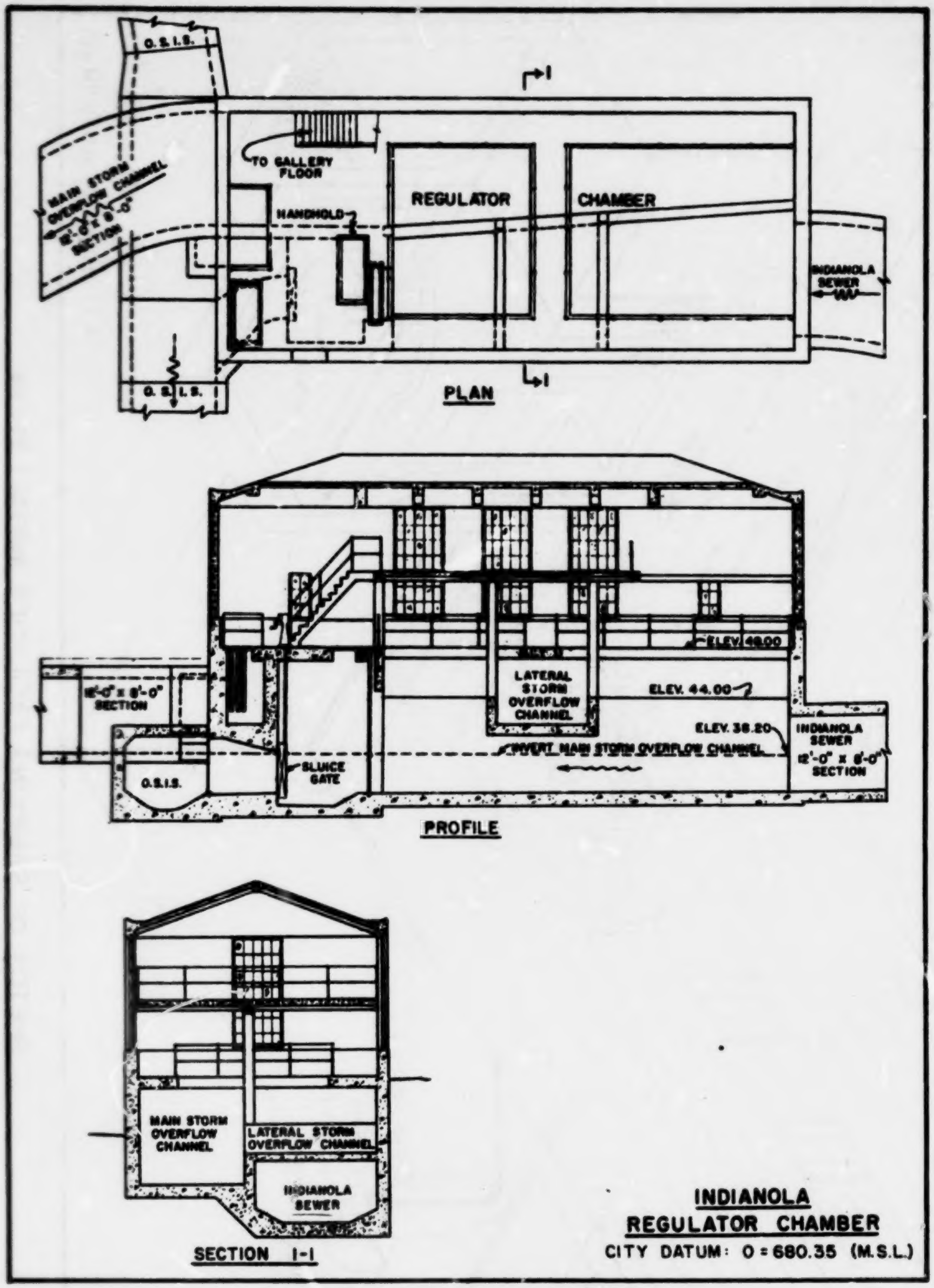
The general features of the storm standby tank facilities are shown in Figures 3, 4 and 5. Any details desired can be obtained from the previously referenced study for the original tanks.

Regulator Stations

There are 16 regulator stations (also referred to as regulator chambers) on the O.S.I.S. between Hudson Street and Whittier Street. Dry weather flow from the combined sewers passes through these regulator stations to the O.S.I.S. For storm periods, the operation of sluice gates in the station can be used to limit the volume of flow which will be passed to the O.S.I.S., with the excess accumulating and rising in the station until it overflows the weirs and then is carried to the river. The sluice gates at all stations are set to pass a predetermined maximum flow into the O.S.I.S. to eliminate manual operation during storm periods, which would be hazardous. Sometimes the regulator stations have been filled to the ceiling of the chamber. Figure 6 represents a more or less typical regulator station, except for the superstructure which was added by Ohio State University and is used by the Water Resource Department of the school.

Regulator stations were designed to limit the average number of storm overflows to the river to not more than 4 per year for stations in the central part of the city, and not more than 8 per year for stations north and south of the central business section. The original design study indicates that 4 overflows per year would result from rainfalls of 0.9 inch in 1/2 hour, 0.4 inch in 1 hour, and 0.6 inch in 2 hours; and that rainfalls of 0.7 inch in 1/2 hour, 0.3 inch in 1 hour, and 0.4 inch in 2 hours would produce 8 overflows per year. Technical Paper No. 40 (Frequency Atlas of the United States), prepared by the U. S. Weather Bureau, shows the 1 year frequency for rainfall in the Columbus area to be 0.8, 1.0 and 1.2 inches, respectively, for durations of 1/2, 1 and 2 hours. In the period July 1, 1968 to June 30, 1969 overflows to the river occurred 16 times at the Indianola Regulator Station located on the University Campus and 14 times at the Spruce Street Station on the fringe of the commercial district of Columbus. Six overflows at the Indianola Station and 4 at the Spruce Street Station occurred within 24 hours of another overflow and were in the same overall storms. On that basis, the number of overflows for the above year period would be ten for each station. An annual rainfall almost three inches above normal occurred at the downtown Weather Bureau Station during this period and probably was responsible in part for the excessive number of overflows. However, the principal cause is the reduction in sluice gate opening which controls the amount of flow into the O.S.I.S. For the period of this study for which gage records were kept, the least rainfall recorded to place the regulator stations in operation was 0.4 inch for the Indianola Station in a two-hour period and 0.5 inch for the Spruce Street Station, also in a two-hour period.

More detailed descriptions of the existing facilities outlined above can be found in the American Society of Civil Engineer's transactions previously mentioned.


O.S.I.S.
MAIN STORM OVERFLOW CHANNEL 12'-0" x 8'-0" SECTION
TO GALLERY FLOOR
HANDHOLD
REGULATOR
CHAMBER
INDIANOLA SEWER
O.S.I.S.
PLAN
1
1
ELEV. 49.00
12'-0" x 8'-0" SECTION
LATERAL STORM OVERFLOW CHANNEL
ELEV. 44.00
ELEV. 38.20
INDIANOLA SEWER 12'-0" x 8'-0" SECTION
INVERT MAIN STORM OVERFLOW CHANNEL
O.S.I.S.
SLUICE GATE
PROFILE
MAIN STORM OVERFLOW CHANNEL
LATERAL STORM OVERFLOW CHANNEL
INDIANOLA SEWER
SECTION 1-1
INDIANOLA
REGULATOR CHAMBER
CITY DATUM: 0 = 680.35 (M.S.L.)

PLAN AND SECTIONS OF REGULATOR STATION

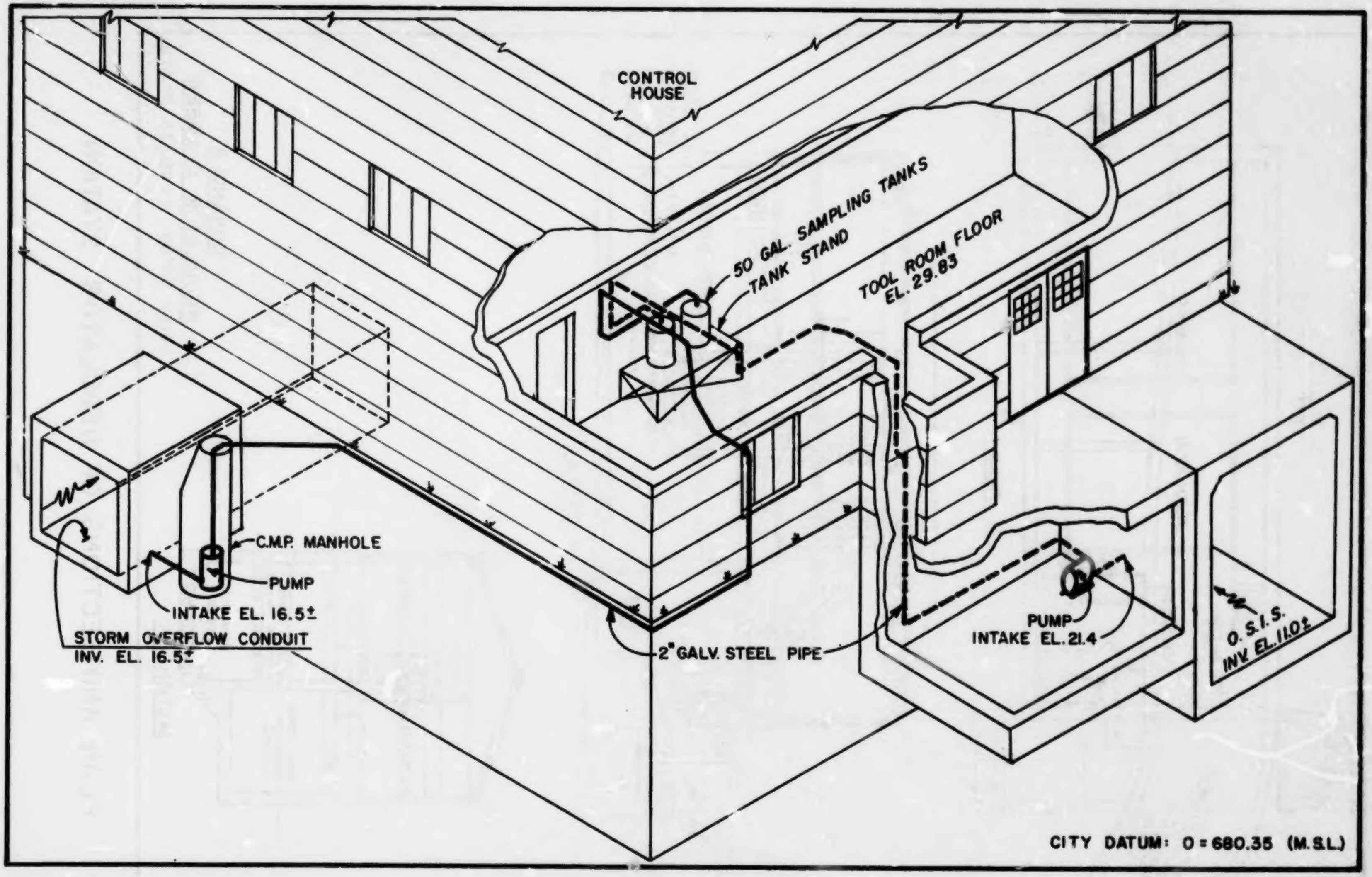


FIGURE 7 SKETCH OF SAMPLING FACILITIES INSTALLATION

SECTION V

INSTALLATION OF EQUIPMENT FOR PROJECT

General

Some of the instruments needed for the study were available and were used. Other existing instruments were considered but rejected because it was believed that the results from them were not sufficiently accurate.

Recording Rainfall Gages

When the study was initiated only two official recording rainfall gages were in operation in, or close to, the watershed, namely, the U.S. Weather Bureau Station at the Federal Building in downtown Columbus and a gage on the grounds of the Ohio State University Farm on the west bank of the Olentangy River opposite the main campus. Another recording gage was located on the University Campus at the Water Resources Building but was not operative at the time. These three gages do not give satisfactory coverage of the watershed for the combined sewer areas. Although flows from sanitary sewers outside the combined sewer area enter the O.S.I.S. (and probably carry some storm water from illegal connections), it was not considered necessary to have enough gages to cover the entire watershed above the Whittier Street Storm Standby Tanks. Four recording rainfall gages were installed at Fire Stations (see Figure 1), which together with the three existing gages were considered adequate to provide a reasonable basis for determining the intensity and volume of rainfall over the watershed of the O.S.I.S. The weighted rainfall over the O.S.I.S. watershed for each storm during which sampling operations were under way was determined by the Thiessen Method.

The four additional gages obtained for this study were Stevens Precipitation Recorders, Type Q6, having a capacity of 12 inches with an 8-day spring-driven clock. The four gages, plus the Water Resource gage, were maintained on a weekly basis by the contractor from May 1968 through October 1969. Arrangements were made with the National Weather Records Center at Ashville, North Carolina, to receive on a monthly basis copies of weekly charts or hourly tabulations of rainfall for the U.S. Weather Bureau gage and the University Farm gage.

Water Level Recorders

Facilities were installed in the modification of the storm standby tanks to record the water level in the O.S.I.S. upstream and downstream of the regulator gates, and in the river chamber of the control house, by means of pressure devices. Similar facilities were installed to record the water level in the storm standby tanks. Although these recorders are sufficiently accurate to provide the operators at the Jackson Pike Treatment Plant sufficient information to determine the necessary operation of various gates at the Whittier Street Station, it was believed that the usual float type recorders were needed to provide more accurate records.

Two water level recorders were installed in the O.S.I.S. upstream of Tank No. 3, requiring the drilling of holes through the roof of the sewer. One was about 90 feet upstream of the tanks and the other about 200 feet farther upstream. Stevens Type F recorders were mounted on steel plates welded around the top of 6-inch steel pipe used for a float well extending from 5 feet above to 4 feet below the top of the O.S.I.S. This permitted recording water levels in the O.S.I.S. as low as Elevation 706.2, or 0.8 foot below the level when the tanks go into operation However, the gage records did not prove to be useful because the difference in water levels at the two gages was insignificant. Total flows in the O.S.I.S. were established by the summation of the flows going past the regulator gate, or gates, over the weirs of the tanks and when used, past one or more emergency gates.

The same type water level recorders were provided for each of the storm standby tanks (see Figure 2). They were placed on steel stands supported by the baffle wall located about 3 feet from the overflow weirs at the end of the tanks. Six-inch steel pipe used for float wells extended to Elevation 706.5 or about 0.1 foot below the top of the overflow weirs.

Only two regulator stations were suitable for installation of water level recorders because all others were located in streets or sidewalks where above-ground installations were impracticable. Installations using the same type recorders were made at the Indianola Regulator Station on the Ohio State University Campus and at the Spruce Street Station located within a small open area created by the construction of the north leg of the Innerbelt. The installations were similar to the installations for the O.S.I.S. at the Whittier Street Plant.

All of the gages at the Whittier Street Station have gage scales of 1:5 (smallest divisions 0.05 foot and 2 hours), having a water level range of 5 feet. The gages at the regulator stations have gage scales of 1:10 (smallest divisions of 0.10 foot and 2 hours), having a water level range of 10 feet. All gages had 8-day spring-driven clocks, and were maintained on a weekly basis throughout the study period.

Sampling Facilities

A sketch of the locations of facilities for sampling the flow in the O.S.I.S. and the flow from the storm standby tanks is presented in Figure 7. The most practical and economical location for obtaining samples of influent to the tanks is from a room in the Control House adjacent to the O.S.I.S. The room is reached from the Tool Room and has a floor elevation of 710.18 feet (m.s.l.). The centerline of the 2-inch pipe into the O.S.I.S. was installed at Elevation 701.85, which is 3.0 feet above the invert of intake gates to the tanks but 5.15 feet below the elevation at which the intake gates open and the tanks go into operation. The elevation of the intake pipe is about one foot above the invert of the Emergency Gates and about 11 feet above the invert of the Regulator Gates and the O.S.I.S.

The intake for the effluent sampling was located about 5 feet east of the Control House on the north side of the overflow conduit, and about 185 feet downstream of the southernmost end of the storm standby tanks. Construction of a manhole was necessary for housing a pump and motor. The invert elevation of the storm overflow conduit at the intake is about 696.5± feet (m.s.l.) with the centerline of the intake pipe at Elevation 696.6±(m.s.l.).

Non-clog pumps were installed for each intake, a horizontal for the influent line and a vertical for the effluent. Two-inch steel pipes were installed from the pumps to two 50-gallon tanks placed in the Tool Room. Controls for operating the pumps were installed near the tanks. Drains for the tank were connected to a floor drain leading to the O.S.I.S.

A refrigerator was placed in the Tool Room to store the composite samples until delivery to the testing laboratory.

SECTION VI

SAMPLING PROCEDURES

General

Prior to initiation of the project, the type of samples to be obtained, the data to be recorded, and the tests to be made at the site; and the laboratory tests to be made, were established by representatives of Federal Water Quality Administration and the Department of Public Service of the City of Columbus. Also established was the time interval between sampling and the period over which a composite sample would be collected. The manner in which the sampling was accomplished and data recorded at the site is outlined below.

Samples for laboratory analysis were composited over an 8-hour period. For the first period samples were obtained every 30 minutes, for the second and third periods, every hour, and for all periods thereafter in any storm, every two hours. This schedule was followed until Storm 18 when the time interval for the fourth and succeeding periods was reduced to one hour, and again for all storms after Storm 21 when the time interval for all periods was one hour. Samples were obtained for two laboratories for Storms 18 through 21 and Storm 25; and for three laboratories for Storms 22, 23, and 24.

Prior to taking samples, the pumps for the influent and effluent lines were started and allowed to discharge waste water into and out of the barrels for at least five minutes. A long wood stopper was then placed in the drain of the tank and the tank allowed to fill to about the three-quarter point. A bucket sample was then taken from the top third of the waste water. When the tank is filling the waste water is constantly moving rather rapidly due to the quantity of flow being dumped at a high velocity. Immediately upon removing the bucket, a thermometer was placed in the sample and a 4-ounce bottle for dissolved oxygen tests filled (except for allowance for fixing solutions) by submerging all except a portion of its mouth, being careful to avoid air entrainment. Between three-fourths and one inch of fixing solution was then injected into the bottle and a glass stopper placed in its throat. After marking the sample number on the bottle, the temperature was then recorded. The pH recorder was then checked (the buffer solution replaced if necessary), the probe placed in the waste water, the pH read and recorded. The sample remaining in the bucket was then gently stirred and a half pint sample for 30-minute sampling periods, one pint for one-hour and one quart for 2-hour sampling periods poured into a gallon jug and placed in the refrigerator immediately. This procedure was followed for both the influent and effluent samples.

Between sampling operations, the water level recorders on the O.S.I.S. and the tanks were checked to determine if they were operating properly. Likewise, operation of the sludge scraper for each tank was observed and the status recorded as "operating" or "stopped," recording the time when

not operating. The opening of each regulator gate as indicated on the dial on the gate stand was checked at one-half hour intervals and any changed recorded.

In order to obtain more data on the effectiveness of the storm standby tanks when detention periods were longer, the emergency gates were operated a number of times for short periods to decrease the volume passing through the tanks. This, of course, is an operation which should be done only when the flow is of such great magnitude that it could not pass through the tanks without overtopping its walls. Under present conditions at the Jackson Pike Plant, it is considered better to bypass excess flows through the Whittier Street tanks to the river than to open the regulator gates and overload the plant.

SECTION VII

LABORATORY TESTING

Tests Needed for Evaluation Program

As stated in the previous section of this report, the laboratory tests needed to evaluate the operation of the tanks were established by the Federal Water Quality Administration, together with representatives of the City of Columbus. The following tests were made (or computed) for each composite sample obtained: total solids, total volatile solids, total fixed solids, total suspended solids, total suspended volatile solids, total suspended fixed solids, settleable solids, ether solubles, biochemical oxygen demand (5 days at 20° C.), and coli (MPN).

Tests for the dissolved oxygen content of each sample taken at the specified intervals in the eight-hour period were also made. The results of the eight individual tests on samples were then averaged to give the average dissolved oxygen for the eight-hour period. For each dissolved oxygen sample the laboratory computed the dissolved oxygen to saturation and the percent saturation of dissolved oxygen.

No changes in the kinds of laboratory tests to be made were considered until Storm 14 (January 17-19, 1969) when the coli (MPN) test was discontinued. All influent and effluent samples had strong concentrations of coli (MPN), indicating that passing the waste water through the tanks had little, if any, effect on reducing the concentrations.

Laboratory Facilities Utilized

The magnitude of the laboratory work envisioned at the beginning of the program, and that which actually was performed, was anticipated by both the City and State Officials. These agencies believed that they could not make all the required laboratory tests without neglecting their regular routine work, because they did not have sufficient qualified help to take on the extra work load. Consequently, it was necessary to resort to having the laboratory testing done by a commercial organization, preferably one in the metropolitan Columbus area so samples might be taken to the laboratory as soon as practicable after they were obtained. The Columbus Water and Chemical Testing Laboratory, in Columbus, was selected as one which would be able to do the type of work required, inasmuch as it had, and was performing similar work for communities in central Ohio. The firm has been approved by the Department of Health, State of Ohio, for doing this type of work. Testing is done according to Standard Methods for Examination of Water and Waste Water.

Storms Selected for Analysis

Sampling was done during 24 different storms, however, some were for very short periods of tank operation--less than four hours. Since sampling operations began shortly after the construction modifications had been completed, a number of occasions were experienced when the modified tank facilities were not operating properly necessitating adjustments in the mechanical and electrical equipment. The sludge scrapers were out of order a considerable portion of the time and at other times intake gates to some of the tanks would not open. Therefore, it was considered advisable to limit the evaluation of the laboratory data to Storms 9 through 24 (actually Storm 24 was sampled as two storms, because sampling was stopped with completion of period 24-5 due to falling depth over tank weirs and to the fact that no rain had occurred for 12 hours; however, it started to rain again 6 hours later and sampling was resumed 2 hours afterwards and the period designated 25-1 then, is now designated 24-7).

Duplicate samples were obtained for five storms (18, 19, 20, 21, and 25) with tests for the extra sample being performed by the State Health Department.

Triplicate samples were taken for three storms (22, 23, and 24) with the third sample being tested by the City of Columbus, Jackson Pike Waste Treatment Laboratory. The results of all laboratory testing are presented in Appendix A.

SECTION VIII

ANALYSIS OF LABORATORY TESTS

General

Prior to analysis and evaluation of the results of the laboratory tests for this study, the characteristics of the normal dry weather flow of the O.S.I.S. were established to provide a guide to the reasonableness of influent concentrations of the O.S.I.S. waste water samples during storm periods. Based on the 1969 record, the normal dry weather flow (71 MGD) at the Jackson Pike Waste Treatment Plant had the following ranges of concentrations:

Total solids	800 - 950 mg/l
Total suspended solids	200 - 350 mg/l
Settleable solids (estimated)	2.0 - 3.5 ml/l
Biochemical Oxygen Demand (hereafter noted as B.O.D.)	150 - 300 mg/l

The range of concentrations for settleable solids is based on the relationship of Total Suspended Solids to Settleable Solids as determined by laboratory tests (see page 41).

The concentrations at the Whittier Street Storm Standby Tanks for the dry weather flow (35 MGD) are considered to be the same as at the Jackson Pike Plant. The developments within the watershed above Jackson Pike Plant as a whole and that of the O.S.I.S. above Whittier Street are essentially the same, indicating concentrations for dry weather flow should be of reasonably like magnitude. Under the prevailing City policy, all industrial plants are required to treat industrial wastes before discharging them into the public sewer system. The results of laboratory tests of the O.S.I.S. waste water before it enters the tank reflect the dilution from storm runoff both from the standpoint of intensity and volume of precipitation. It can be expected that at the start of the storm period, the storm water portion of the O.S.I.S. flow will have a fairly large concentration of solids due to the flushing action resulting from surface runoff in built-up areas to storm sewer inlets. In the middle of a storm, less solids are likely to be in the storm water, and several hours after rainfall has stopped, solids of storm water usually have decreased very much and the continuing storm water portion of the total O.S.I.S. flow is probably infiltration from foundation drains and trunk sewers. However, the concentrations of O.S.I.S. flow as a whole will be substantially less than that for the normal dry weather flow. As storm runoff subsides, flows at Whittier Street decrease considerably and concentrations increase until the flow has dropped to about 100 MGD when concentrations tend to approach dry weather flow conditions, except for total suspended solids which remain, in most cases, at a level of about 100 mg/l less than the values for the normal flow.

Preliminary Analysis of Laboratory Tests

Table 1 Page 33 presents pertinent data for all storms having 3 or more 8-hour periods, together with the results of laboratory tests for total solids, total suspended solids, settleable solids, B.O.D., and dissolved oxygen. Figures 8 to 21 inclusive show the same data graphically.

Certain general relationships can be noted between the flow in the O.S.I.S. and the influent concentrations for total solids, total suspended solids, settleable solids and B.O.D. After the peak flow of a storm or after secondary peak flows, total solids generally tend to become more concentrated but are still less concentrated than the total solids in dry weather flow periods. When the flow in a period succeeding the peak flow drops decidedly, the total suspended solids and settleable solids concentrations are much less. After this sharp drop, concentrations increase generally with a decrease in O.S.I.S. flow but do not in most instances reach the concentration recorded at the peak flow periods. The concentration pattern for the B.O.D. influent samples also show generally an increase with a decrease in O.S.I.S. flow. With respect to the effluent concentrations for the various tests, the pattern or trends are not so obvious because another factor, "detention time," is involved.

Some of the concentrations shown for tests are not compatible with the results of other tests from the same composite sample or with results of the tests for its opposing sample (influent or effluent). These differences stand out very clearly in the charts referred to subsequently in the discussions of the detailed analyses of the tests. The specific reason for each case in which a laboratory test result is out of line cannot be established with absolute authority. An error in making or recording the results of the test, or in the sampling operation by placing some samples in the wrong jug, or by not getting a truly representative sample from the bucket appear to be the only plausible reasons for the non-conformance of those results to the expected results. Such cases are relatively few. They will be discussed later in the pertinent detailed analyses.

Scope of Detailed Analyses

Based on the preliminary analysis it appeared advisable to divide the test results into two groups because of the wide range in values. One group (designated Group I) consists of 8-hour periods during which, or immediately prior thereto, substantial rainfall occurred and the storm water portion of the O.S.I.S. flow is primarily surface runoff. Flows in these periods are usually of considerable magnitude. Retarded storm runoff (temporary storage in sewers), infiltration and illegal connections

WHITTIER STREET STORM STANDBY TANKS

PERTINENT DATA AND LABORATORY RESULTS FOR SELECTED STORMS

Storm No.	Date and Period 1969		Rainfall			O.S.I.S. Flow in MGD		Influent Concentrations					Detention Time (min.)	Effluent Concentrations				
			Prior 8 Hrs.	In Period	Accum.	Range	Average	mg/1 T.S.	mg/1 T.S.S.	ml/1 S.S.	mg/1 B.O.D.	D.O. % Sat.		T.S.	T.S.S.	S.S.	B.O.D.	D.O. % Sat.
14-1	1/17&18		0.48	0.40	0.88	300-130	203	514	222	2.5	100	62	28	480	226	2.0	120	71
14-2	1/18	*	-	0.05	0.93	130-90	115	536	94	1.1	130	67	62	448	86	1.0	105	71
14-3	1/18	*	-	-0-	0.93	90-60	79	644	114	2.0	120	47	82	614	82	0.7	90	53
14-4	1/18	*	-	-0-	0.93	75-50	59	676	108	2.0	320	39	216	572	60	Trace	90	55
15-1	1/28		0.25	0.18	0.43	90-130	110	630	250	2.5	180	42	76	502	132	0.6	100	60
15-2	1/29		-	0.63	1.05	80-1030	385	620	300	2.5	100	56	17	462	278	1.5	120	65
15-3	1/29		-	0.17	1.22	50-270	161	582	152	1.9	160	48	61	598	100	1.0	60	66
15-4	1/29		-	0.48	1.70	230-410	287	270	176	2.0	120	67	28	428	192	1.0	40	72
15-5	1/30		-	0.18	1.88	180-250	212	484	90	0.9	120	68	27	518	150	0.7	40	75
15-6	1/30		-	0.19	2.07	190-230	227	532	82	1.6	40	74	25	530	84	1.6	60	80
15-7	1/30		-	0.05	2.12	160-220	192	570	96	0.5	200	61	30	772	104	0.6	190	66
15-8	1/31		-	-0-	2.12	120-150	142	694	76	0.3	260	61	41	628	72	0.3	130	72
15-9	1/31		-	-0-	2.12	120-150	134	726	100	0.7	200	58	44	686	76	0.4	130	73
16-1	2/8&9	*	0.52	0.28	0.80	160-250	200	408	156	1.3	80	58	28	444	208	1.3	60	63
16-2	2/9	**	-	-0-	0.80	90-240	108	410	52	0.1	80	62	55	578	58	0.2	40	70
16-3	2/9	**	-	-0-	0.80	80-100	99	620	68	0.2	120	54	62	598	44	0.2	40	65
18-1	4/18		0.92	0.23	1.15	410-120	208	445	138	2.0	104	34	31	401	150	1.25	48	50
18-2	4/18		-	0.85	2.00	830-160	383	474	307	3.0	74	55	30	438	246	1.45	57	66
18-3	4/19	*	-	-0-	2.00	160-120	139	525	68	0.58	59	60	42	543	58	0.85	31	72
18-4	4/19	*	-	-0-	2.00	120-180	135	590	76	0.95	85	63	48	605	81	0.55	60	66
18-5	4/19	*	-	-0-	2.00	140-110	114	538	89	1.05	85	51	55	546	91	0.9	116	62
19-1	5/8		0.88	0.57	1.45	960-140	361	648	334	2.3	56	39	19	546	277	1.35	40	52
19-2	5/9		-	0.05	1.50	140-120	131	608	116	1.35	40	52	49	537	74	0.75	21	64
19-3	5/9		-	0.05	1.55	140-100	126	657	144	2.5	97	40	47	588	101	1.35	70	55
19-4	5/9		-	0.07	1.62	100-140	114	708	134	1.8	107	40	58	666	97	0.4	69	51
23-1	6/13		0.75	1.35	2.10	70-750	225	392	161	1.7	55	25	38	343	126	1.2	42	39
23-2	6/13		-	0.04	2.14	480-100	215	526	147	1.63	59	47	69	407	123	1.07	38	64
23-3	6/13		-	-0-	2.14	100-80	87	625	83	1.13	99	10	70	627	79	0.37	75	34
24-1	6/22	**	0.35	0.77	1.12	340-50	136	35[illegible]	96	1.07	70	8	49	322	73	0.63	56	35
24-2	6/23		-	0.91	2.03	740-150	395	443	211	1.53	51	54	32	378	149	1.13	36	65
24-3	6/23		-	0.05	2.08	190-140	160	596	109	1.6	77	53	36	573	79	1.47	55	64
24-4	6/23		-	0.22	2.30	120-580	208	609	215	1.83	68	51	31	569	168	1.57	60	59
24-5	6/24		-	-0-	2.30	120-60	100	602	48	0.6	50	44	68	590	51	0.53	41	57
24-6	6/24		-	0.08	2.38	60-100	85	No sampling in this period										
24-7	6/24		-	0.92	3.30	90-930	367	513	207	1.65	35	54	25	430	156	1.4	30	63
24-8	6/25		-	-0-	3.30	225-90	137	562	45	1.2	25	55	44	503	45	0.65	16	66
24-9	6/25		-	-0-	3.30	90-120	110	648	103	2.35	111	39	71	594	67	0.45	75	50
24-10	6/26		-	-0-	3.30	100-70	90	681	140	1.95	152	21	115	669	82	0.5	151	30

Notes: Unless otherwise indicated, storm periods occurred Monday through Friday. * Indicates Saturday ** Indicates Sunday
Sampling stopped after 24-5 Period; falling gage indicated overflow would probably end soon. Rainfall started again and sampling resumed 8 hrs. later

Abbreviations: T.S.- Total Solids; T.S.S.- Total Suspended Solids; S.S.- Settleable Solids; B.O.D.- Biochemical Oxygen Demand; D.O.- Dissolved Oxygen

Table 1

(foundation drains) to the sewer system are the principal components of Group II storm period flows, which are in most instances of lesser magnitude than Group I flows. However, these Group II periods having the higher rates of flow could fall within or close to the Group I parameters. Storm period 23-2 for example, could be in either group but it fits Group I parameters better.

When tests were made by more than one laboratory the average concentration for the test was normally accepted. Exceptions have been made where the results were not agreeing very closely. Only two of the three test results were averaged when one was clearly out of line, and only one of two when the other test result did not fall within the range to be expected. For Storms 9 through 17 when only one laboratory was testing, a number of results were outside the range to be expected or not compatible with other tests of the same sample. All of these exceptions are discussed later under one or more of the tests.

Detailed analyses of all laboratory test results for Storms 9 through 24 were made with the view of establishing parameters and means of concentration as related to the magnitude of the O.S.I.S. flow with consideration of the effect of detention time on effluent concentrations. Analyses were made of total solids, total dissolved solids, total suspended solids, settleable solids, B.O.D., and dissolved oxygen. For each group, influent concentrations of all composite samples are plotted against the total 8-hour average flow of the O.S.I.S. for the period when the sample was taken. The period of the day when the composite sample was taken and the average temperature of individual samples comprising the composite sample are distinguished by symbols. In order to present comparable information for effluent concentrations, the quantity of flow by-passing the tanks by continuing in the O.S.I.S. and the quantity of flow passing through the emergency gates must be considered because both factors affect the length of the detention period.

Since the length of the detention time has much to do with the removal of concentrations of solids and B.O.D. of the influent, removal (in percent) versus detention time (in minutes) curves were developed. Parameter curves were drawn encompassing the majority of plotted points derived from the actual influent and effluent values, giving more weight to periods in which the influent values were greater and ignoring those with negative removal values and other points falling far from the pattern of plotted points. The mean percent removal curves were drawn half-way between the parameter curves.

It is evident that for the same magnitude of flow in the O.S.I.S., different detention times can be established by limiting the flow through the tanks. The extent of expected reduction in concentrations can be increased or decreased with an increase or decrease in detention time. There is no direct manner in which these two factors can be used to show the relationship of effluent concentration to the O.S.I.S. flow.

Consequently, the mean influent and the mean percent removal curves for the pertinent test in a Group have been used to establish a mean effluent concentration curve, which can be expected, for the detention time and the bypass flow applicable to the period for the pair of samples. The manner in which this has been done is best explained by reference to Figure 25, Total Suspended Solids Removal; Figure 22, rating curve for Flow through Tanks versus Detention Time; and Figure 27, Total Suspended Solids Concentration, Effluent, versus Total Flow in O.S.I.S., under several conditions of bypassing part of the O.S.I.S. flows around the tanks. The first step is to plot the mean influent curve for total suspended solids shown on Figure 23 on the last-mentioned curve above. Assume the tanks do not go into operation until the O.S.I.S. flow exceeds 35 MGD when the regulator gates are closed and all flow is passed through the tanks. Figure 23 indicates an influent concentration of 275 mg/l and Figure 22 shows a detention time of 145 minutes for a flow of 35 MGD. Figure 25 indicates that the mean removal of total suspended solids at such detention time is 48 percent which results in an expected effluent concentration of 143 mg/l. This value is plotted on Figure 27 and represents the effluent value for a flow in the O.S.I.S. of 35 MGD, all of which is going through the tank. For another example of how the curves are derived, assume the O.S.I.S. flow is 200 MGD and all is passed through the tanks, the detention time is 27 minutes, and the percent removal to be expected is 20 percent, resulting in an expected effluent concentration of 138 mg/l (80% of the influent value of 172). Now assume that the total flow of the O.S.I.S. again is 200 MGD, but that 100 MGD is to be bypassed, the detention time is 54 minutes and the expected percent removal is 32. The expected effluent concentration is then 68% of 172, or 117 mg/l. The extent to which actual values for effluent concentrations vary considerably from the expected values is discussed below for each type of test. The actual effluent values are plotted on the figures showing the expected effluent concentrations.

Total Suspended Solids

It has been stated earlier in this section that the concentration of total suspended solids in the dry weather flow of the O.S.I.S. ranges between 200 and 350 mg/l. For Storms 9 through 24 the laboratory tests of influent samples show a range in values from 96 to 334 mg/l for Group I, and 45 to 144 mg/l for Group II samples. The higher concentrations occur when the flows in the O.S.I.S. are over 200 MGD and all are in Group I.

The test results for total suspended solids for all composite influent samples in Group I are shown in Figure 23 and for Group II in Figure 24. The general trend of concentrations in Group I samples is to decrease as O.S.I.S. flow increases to about 160 MGD and then to increase as the flow in the O.S.I.S. increases. This phenomenon indicates the storm water resulting from the high intensity rainfall contains a substantial amount of total suspended solids. The time of the day in which the sample is taken appears to have no significant effect on the total suspended solid concentrations. The parameters shown in Figure 23 were established by beginning at 200 and 350 mg/l and decreasing to 50 mg/l either side of the mean influent curve, encompassing all but a few of the plotted values. The sample for the 19-1 Storm Period was taken when the flow in the O.S.I.S. had an hourly peak flow of 960 MGD and an average flow for the period of 361 MGD. Consequently, the concentration was probably affected by the flushing action resulting from an intense runoff from a rainfall of 1.15 inches prior to the start of the period and 0.3 inch during period. The sampling period for Storm 20 began over 12 hours after the tanks started to fill. Since no rainfall was recorded immediately before, and only a minor amount during the period, the period could be classed with the Group II periods and would fall within the parameters for that group. Other values plotted outside the parameters do not appear to have any specific reason for being greater (15-1) or less (24-1 and 24-2) than expected concentrations. It might be noted that the 24-1 period occurred on a Sunday evening when concentrations are expected to be low and 24-2 between midnight on Sunday to 8 A.M. on Monday.

Figure 24 shows the influent concentrations versus the total O.S.I.S. flow for Group II samples. It will be noted that concentrations decrease following a Group I sample and then increase with a decrease in O.S.I.S. flow. Since little or no rainfall has occurred in most periods for Group II, the sanitary waste becomes a larger proportion, and the solids in the storm water probably a lesser part of the total waste water as the O.S.I.S. flow decreases. Figure 24 shows how the mean influent of Group I recedes into the mean influent for Group II values. The general trends are essentially the same for all the three time periods of the day, even though samples for the midnight to 8 A.M. period have lower concentrations. The parameters of the influent, of course, are the same as for Group I.

Effluent concentrations which can be expected for Group I and Group II samples and the actual values are shown on Figures 27 and 28. Obviously the curves indicating the concentrations to be expected with various flows being by-passed around the tank follow more or less the shapes of the influent curves for Groups I and II. These effluent curves are mean curves and parameters somewhat less than 50 mg/l (parameters for the influent) would be applicable. Of the 24 composite effluent samples in Group I, the concentrations determined by the laboratory for nine samples were between 41 and 91 mg/l greater or less than the expected mean effluent concentrations. Four of these samples (13, 14-1, 15-2, and 16-1) were taken when the temperature of the waste water was low (less than 10° C). Consequently, the efficiency of settling of solids can be expected to be less. All had effluent values even greater than the expected mean influent concentrations for the Group I samples. The effluent concentration for Storm 19-1 is 62 mg/l higher than the expected value and is believed directly due to its unusually high influent concentration (79 mg/l higher than the expected value). Two of the samples (24-2 and 24-7) had greater than average removals than could be expected for the detention times pertinent to the samples. Sample 10-1 had an exceptionally high percentage of removal (59%) for a detention time of

55 minutes (see Figure 25), resulting in abnormally low effluent concentration. The ninth sample (24-1) had a concentration of only 42 mg/l, which is not much outside of any reasonable limit of the expected mean value.

Only four of the 26 composite samples in Group II had concentrations over 40 mg/l greater or less than the expected mean effluent concentrations. Three of these samples have effluent concentrations greater than values for corresponding influent concentrations. The fourth sample has a concentration greater than the expected mean influent concentrations. Table 2 presents the expected concentrations and actual concentrations for all the samples tested for Storms 9 through 24.

Total Solids

Dissolved solids have been considered even though no removals are expected, by passing waste water through the tanks, because more consistent results can be obtained regarding determination of expected effluent concentrations for total solids by taking an indirect approach. It will be noted on Table 2, that actual influent and effluent concentrations of dissolved solids for several samples are far from being essentially the same, and others are not within the range of values to be expected normally. Therefore, the computed dissolved solids values for each influent and the corresponding effluent sample were averaged and used in establishing the mean curve and parameters for dissolved solids curves for each group of samples, see Figures 29 and 30.

The mean dissolved solids curves for Groups I and II samples were then plotted on Figures 33 and 34, which show total solids concentrations versus total O.S.I.S. flow and designated Group I and Group II effluent samples. On Figures 31 and 32, two mean total solids influent concentration versus total flow in O.S.I.S. are shown for each group. Values of concentration for total solids tests in Storm 15 have not been used in establishing the parameters because six of nine samples are not in the range to be expected for the pertinent flows. One curve is based directly on the values determined by laboratory tests for total solids, and the other on the summation of the concentration for the mean dissolved solids curve cited above and the mean influent concentration curve for total suspended solids (Figures 23 and 24). For each Group the latter curve was plotted on the appropriate effluent sample figure referred to above and is designated mean influent total solids. The mean effluent curves for total suspended solids are then superimposed on the mean dissolved solid curves to establish effluent curves for total solids.

Five samples, excluding Storm 15 samples, fall outside parameters which have values 75± mg/l from the mean influent curve for Group I (see Figure 31). Two samples (10-1 and 11) are only slightly beyond the limits, 2 and 13 mg/l. Sample 24-1 has a total solids value of only 354 mg/l which is considerably less than can be expected. The other two samples (19-1 and 24-4) have rather high total solids concentrations - 153 and 149 mg/l greater than the mean total solids values. Both have total dissolved solids greater than the expected values.

WHITTIER STREET STORM STANDBY TANKS

ACTUAL AND EXPECTED CONCENTRATIONS FOR COMPOSITE SAMPLES

GROUP I

Storm No.	Total O.S.I.S. Flow MGD	By-Pass Flow MGD	Detention Time Min.	Temperature °C	Total Solids Influent Act. mg/1	Total Solids Influent Exp. mg/1	Total Solids Effluent Act. mg/1	Total Solids Effluent Exp. mg/1	Total Suspended Sol. Influent Act. mg/1	Total Suspended Sol. Influent Exp. mg/1	Total Suspended Sol. Effluent Act. mg/1	Total Suspended Sol. Effluent Exp. mg/1	Total Dissolved Solids Infl. Act. mg/1	Total Dissolved Solids Effl. Act. mg/1	Total Dissolved Solids Ave. Act. mg/1	Total Dissolved Solids Exp. I&E mg/1	Settleable Influent Act. ml/1	Settleable Influent Exp. ml/1
9	104	31	74	16.1	498	530	520	470	154	170	134	110	344	386	365	360	1.4	1.95
10-1	109	10	55	15.1	458	535	376	485	128	170	52	120	330	324	327	365	2.1	1.95
11	101	28	74	11.5	648	560	518	490	195	180	120	110	453	398	426	380	1.5	2.0
12-1	136	39	56	10.6	442	500	350	440	138	170	112	110	304	238	271	330	2.3	1.9
13	151	10	38	9.1	460	485	412	440	194	165	186	120	266	226	246	320	2.0	1.9
14-1	203	10	28	8.3	514	460	480	420	222	175	226	135	292	254	273	285	2.5	1.9
15-1	110	39	76	10.3	630	535	502	475	250	170	132	110	380	370	375	365	2.5	1.95
15-2	385 (b)	67	17	9.9	620	505	462	465	300	270	278	230	320	184	252	235	2.5	2.3
15-3	161	72	61	11.6	582	475	598	420	152	165	100	110	430	498	464	310	1.9	1.9
15-4	287	92	28	10.9	270	465	428	425	176	205	192	165	98	236	236*	260	2.0	2.05
16-1	200	10	28	9.1	408	455	444	420	156	170	208	135	252	236	244	285	1.3	1.9
17	105	50	98	12.4	588	545	362	470	214	175	116	100	374	246	310	370	2.2	2.0
18-1	208	31	31	16.3	445	460	401	420	138	175	150	135	307	251	279	285	2.0	1.9
18-2	383 (a)	204	30	13.9	474	505	438	445	307	270	246	210	167	192	179	235	3.0	2.3
19-1	361 (a)	79	19	17.9	648	495	546	455	334	255	277	215	314	269	291	240	2.3	2.25
20	210	10	27	17.8	519	455	515	415	110	175	98	135	409	417	413	280	1.6	1.9
21-1	107	39	80	19.7	522	540	355	480	128	170	81	110	394	274	334	370	1.4	1.95
22-1	135	42	58	18.5	527	500	386	440	147	170	95	110	380	291	335	330	1.6	1.9
23-1	225 (a)	83	38	20.9	392	455	343	405	161	180	126	130	231	217	224	275	1.7	1.9
23-2	215	136	69	20.1	526	455	407	390	147	175	123	110	379	284	331	280	1.63	1.9
24-1	136	26	49	21.3	354	500	322	445	96	170	73	115	258	249	253	330	1.07	1.9
24-2	395 (a)	225	32	19.6	443	515	378	450	211	280	149	215	232	229	230	235	1.53	2.35
24-4	208 (a)	31	31	21.1	609	460	569	420	215	175	168	135	394	401	397	285	1.83	1.9
24-7	367 (a)	151	25	21.1	513	500	430	450	207	260	156	210	306	274	290	240	1.65	2.3

* Use effluent value only

GROUP II

Storm No.	Total O.S.I.S. Flow MGD	By-Pass Flow MGD	Detention Time Min.	Temperature °C	Total Solids Influent Act. mg/1	Total Solids Influent Exp. mg/1	Total Solids Effluent Act. mg/1	Total Solids Effluent Exp. mg/1	Total Suspended Sol. Influent Act. mg/1	Total Suspended Sol. Influent Exp. mg/1	Total Suspended Sol. Effluent Act. mg/1	Total Suspended Sol. Effluent Exp. mg/1	Total Dissolved Solids Infl. Act. mg/1	Total Dissolved Solids Effl. Act. mg/1	Total Dissolved Solids Ave. Act. mg/1	Total Dissolved Solids Exp. I&E mg/1	Settleable Influent Act. ml/1	Settleable Influent Exp. ml/1
10-2	81	50	174	17.0	568	665	480	610	90	120	108	65	478	372	425	545	1.5	1.4
12-2	70	39	174	13.2	432	685	350	625	72	130	40	70	360	310	335	555	0.6	1.55
14-2	115	28	62	10.0	536	610	448	580	94	90	86	60	442	362	402	520	1.1	1.15
14-3	79	13	82	12.0	644	660	614	620	114	115	82	75	530	532	531	545	2.0	1.4
14-4	59	34	216	13.0	676	715	572	645	108	150	60	80	568	512	540	565	2.0	1.7
15-5	212	10	27	11.0	484	545	518	530	90	65	150	50	394	368	381	480	0.9	0.9
15-6	227	10	25	11.6	532	535	530	525	82	60	84	50	450	446	448	475	1.6	0.85
15-7	192	10	30	12.0	570	550	772**	530	96	70	104	50	474	668**	471	480	0.5	0.9
15-8	142	10	41	12.0	694	580	628	555	76	80	72	55	618	556	587	500	0.3	1.0
15-9	134	10	44	12.6	726	585	686	565	100	80	76	60	626	610	618	505	0.7	1.05
16-2	108	10	55	10.7	410	615	578	585	52	95	58	65	358	520	439	520	0.1	1.2
16-3	99	10	62	11.6	620	630	598	600	68	100	44	70	552	554	553	530	0.2	1.25
18-3	139	10	42	13.9	525	580	543	560	68	80	58	60	457	485	471	500	0.58	1.0
18-4	135	22	48	13.9	590	585	605	565	76	80	81	60	514	524	519	505	0.95	1.05
18-5	114	16	55	14.1	538	610	546	585	89	90	91	65	449	455	452	520	1.05	1.15
19-2	131(a)	20	49	16.6	608	590	537	565	116	85	74	60	492	463	477	505	1.35	1.1
19-3	126	10	47	17.3	657	595	588	570	144	85	101	60	513	487	500	510	2.5	1.1
19-4	114	20	58	17.1	708	610	666	585	134	90	97	65	574	569	572	520	1.8	1.15
21-2	85	39	117	19.0	440	650	428	605	122	110	98	65	318	330	324	540	1.2	1.4
22-2	64	40	225	20.6	652	700	563	635	87	140	74	75	565	489	527	560	0.63	1.6
23-3	87	10	70	21.2	625	650	627	610	83	110	79	70	542	548	545	540	1.13	1.35
24-3	160	10	36	19.7	596	565	573	545	109	75	79	55	487	494	490	490	1.60	1.0
24-5	100	20	68	19.6	602	630	590	595	48	100	51	65	554	539	546	530	0.6	1.25
24-8	137	14	44	19.1	562	585	503	565	45	80	45	60	517	458	488	505	1.2	1.05
24-9	110	34	71	20.2	648	615	594	580	103	95	67	60	545	527	536	520	2.35	1.2
24-10	90	43	115	20.9	681	645	669	600	140	110	82	65	541	587	564	535	1.95	1.35

** Adjust effluent value of T.S. from 772 to 572 and change the effluent of T.D.S. from 668 to 468.

(a) Both Indianola and Spruce Street regulator stations are in operation during the period.

(b) Only Spruce Street regulator station in operation.

WHITTIER STREET STORM STANDBY TANKS

ACTUAL AND EXPECTED CONCENTRATIONS FOR COMPOSITE SAMPLES

can- ion n.	Temper- ature	Total Solids				Total Suspended Sol.				Total Dissolved Solids				Settleable Solids				B.O.D. 5 days @ 20°C			
		Influent		Effluent		Influent		Effluent		Infl.	Effl.	Ave.	Exp.	Influent		Effluent		Influent		Effluent	
		Act.	Exp.	Act.	Exp.	Act.	Exp.	Act.	Exp.	Act.	Act.	Act.	I&E	Act.	Exp.	Act.	Exp.	Act.	Exp.	Act.	Exp.
	°C	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	ml/1	ml/1	ml/1	ml/1	mg/1	mg/1	mg/1	mg/1
74	16.1	498	530	520	470	154	170	134	110	344	386	365	360	1.4	1.95	0.7	0.7	125	135	100	90
55	15.1	458	535	376	485	128	170	52	120	330	324	327	365	2.1	1.95	0.1	0.85	250	140	115	100
74	11.5	648	560	518	490	195	180	120	110	453	398	426	380	1.5	2.0	0.3	0.7	185	145	200	95
56	10.6	442	500	350	440	138	170	112	110	304	238	271	330	2.3	1.9	0.4	0.8	130	120	125	85
38	9.1	460	485	412	440	194	165	186	120	266	226	246	320	2.0	1.9	1.3	1.1	100	110	90	80
28	8.3	514	460	480	420	222	175	226	135	292	254	273	285	2.5	1.9	2.0	1.25	100	85	120	70
76	10.3	630	535	502	475	250	170	132	110	380	370	375	365	2.5	1.95	0.6	0.65	180	140	100	90
17	9.9	620	505	462	465	300	270	278	230	320	184	252	235	2.5	2.3	1.5	1.8	100	55	120	45
61	11.6	582	475	598	420	152	165	100	110	430	498	464	310	1.9	1.9	1.0	0.8	160	100	60	70
18	10.9	270	465	428	425	176	205	192	165	98	236	236*	260	2.0	2.05	1.0	1.3	120	65	40	50
28	9.1	408	455	444	420	156	170	208	135	252	236	244	285	1.3	1.9	1.3	1.25	80	85	60	70
98	12.4	588	545	362	470	214	175	116	100	374	246	310	370	2.2	2.0	0.5	0.5	160	140	80	90
31	16.3	445	460	401	420	138	175	150	135	307	251	279	285	2.0	1.9	1.25	1.2	104	80	48	65
30	13.9	474	505	438	445	307	270	246	210	167	192	179	235	3.0	2.3	1.45	1.45	74	55	57	40
19	17.9	648	495	546	455	334	255	277	215	314	269	291	240	2.3	2.25	1.35	1.7	56	55	40	45
27	17.8	519	455	515	415	110	175	98	135	409	417	413	280	1.6	1.9	1.2	1.25	66	80	45	65
80	19.7	522	540	355	480	128	170	81	110	394	274	334	370	1.4	1.95	0.8	0.6	117	140	67	90
58	18.5	527	500	386	440	147	170	95	110	380	291	335	330	1.6	1.9	0.6	0.8	97	115	42	85
38	20.9	392	455	343	405	161	180	126	130	231	217	224	275	1.7	1.9	1.2	1.1	55	75	42	60
69	20.1	526	455	407	390	147	175	123	110	379	284	331	280	1.63	1.9	1.07	0.7	59	80	38	55
49	21.3	354	500	322	445	96	170	73	115	258	249	253	330	1.07	1.9	0.63	0.9	70	120	56	85
32	19.6	443	515	378	450	211	280	149	215	232	229	230	235	1.53	2.35	1.13	1.45	51	50	36	40
31	21.1	609	460	569	420	215	175	168	135	394	401	397	285	1.83	1.9	1.57	1.2	68	80	60	65
25	21.1	513	500	430	450	207	260	156	210	306	274	290	240	1.65	2.3	1.4	1.55	35	55	30	45

7

cen- ion n.	Temper- ature	Total Solids				Total Suspended Sol.				Total Dissolved Solids				Settleable Solids				B.O.D. 5 days @ 20°C			
		Influent		Effluent		Influent		Effluent		Infl.	Effl.	Ave.	Exp.	Influent		Effluent		Influent		Effluent	
		Act.	Exp.	Act.	Exp.	Act.	Exp.	Act.	Exp.	Act.	Act.	Act.	I&E	Act.	Exp.	Act.	Exp.	Act.	Exp.	Act.	Exp.
	°C	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	ml/1	ml/1	ml/1	ml/1	mg/1	mg/1	mg/1	mg/1
74	17.0	568	665	480	610	90	120	108	65	478	372	425	545	1.5	1.4	1.0	0.25	140	105	120	70
74	13.2	432	685	350	625	72	130	40	70	360	310	335	555	0.6	1.55	Tr.	0.3	80	115	60	80
62	10.0	536	610	448	580	94	90	86	60	442	362	402	520	1.1	1.15	1.0	0.5	130	80	105	60
82	12.0	644	660	614	620	114	115	82	75	530	532	531	545	2.0	1.4	0.7	0.5	120	105	90	75
16	13.0	676	715	572	645	108	150	60	80	568	512	540	565	2.0	1.7	Tr.	0.3	320	130	90	90
27	11.0	484	545	518	530	90	65	150	50	394	368	381	480	0.9	0.9	0.7	0.65	120	45	40	40
25	11.6	532	535	530	525	82	60	84	50	450	446	448	475	1.6	0.85	1.6	0.65	40	45	60	35
30	12.0	570	550	772**	530	96	70	104	50	474	668**	471	480	0.5	0.9	0.6	0.6	200	55	190	40
41	12.0	694	580	628	555	76	80	72	55	618	556	587	500	0.3	1.0	0.3	0.6	260	65	130	50
44	12.6	726	585	686	565	100	80	76	60	626	610	618	505	0.7	1.05	0.4	0.6	200	70	130	55
55	10.7	410	615	578	585	52	95	58	65	358	520	439	520	0.1	1.2	0.2	0.6	80	85	40	60
42	11.6	620	630	598	600	68	100	44	70	552	554	553	530	0.2	1.25	0.2	0.55	120	90	40	65
42	13.9	525	580	543	560	68	80	58	60	457	485	471	500	0.58	1.0	0.85	0.6	59	70	31	50
48	13.9	590	585	605	565	76	80	81	60	514	524	519	505	0.95	1.05	0.55	0.55	85	70	60	50
55	14.1	538	610	546	585	89	90	91	65	449	455	452	520	1.05	1.15	0.9	0.55	85	80	116	60
49	16.6	608	590	537	565	116	85	74	60	492	463	477	505	1.35	1.1	0.75	0.55	40	70	21	55
47	17.3	657	595	588	570	144	85	101	60	513	487	500	510	2.5	1.1	1.35	0.6	97	75	70	55
58	17.1	708	610	666	585	134	90	97	65	574	569	572	520	1.8	1.15	0.4	0.5	107	80	69	60
117	19.0	440	650	428	605	122	110	98	65	318	330	324	540	1.2	1.4	0.6	0.3	75	100	61	65
25	20.6	652	700	563	635	87	140	74	75	565	489	527	560	0.63	1.6	0.24	0.3	127	125	89	85
70	21.2	625	650	627	610	83	110	79	70	542	548	545	540	1.13	1.35	0.37	0.55	99	100	75	75
36	19.7	596	565	573	545	109	75	79	55	487	494	490	490	1.60	1.0	1.47	0.6	77	60	55	50
68	19.6	602	630	590	595	48	100	51	65	554	539	546	530	0.6	1.25	0.53	0.5	50	90	41	65
44	19.1	562	585	503	565	45	80	45	60	517	458	488	505	1.2	1.05	0.65	0.6	25	70	16	50
71	20.2	648	615	594	580	103	95	67	60	545	527	536	520	2.35	1.2	0.45	0.45	111	85	75	60
115	20.9	681	645	669	600	140	110	82	65	541	587	564	535	1.95	1.35	0.5	0.35	152	95	151	65

of T.S. from 772 to 572 and change the effluent of T.D.S. from 668 to 468.

Spruce Street regulator stations are in operation during the period.

regulator station in operation.

Table 2

In Group II, Total Solids influent (see Figure 32), four samples excluding Storm 15 samples, have concentrations outside the parameters. Three samples (12-2, 16-2, and 21-2) have total solids concentrations of 440 mg/l or less, which of course are far from normal values to be expected, particularly for the relatively low flows in the O.S.I.S. The other sample, 19-4, has a total solids concentration of 708 mg/l which is substantially above normal.

Table 2 and Figures 33 and 34 show that there are a number of samples which have effluent concentrations of total solids which depart from expected concentrations (75± mg/l) considerably. In Group I, there are 8 samples that fall outside the parameters. The concentrations for 10-1, 12-1, 17, 21-1, and 24-1 ranging from 322 to 376 mg/l appear to be appreciabely below the normal to be expected. If the differences between the average and expected concentrations for total dissolved solids are considered, all values would fall within the parameters. The actual total solids values of effluent are believed to be low for all five samples. On the other hand, for Samples 19-1, 20, and 24-4, the values are believed to be high by the same reasoning - difference between total dissolved solids by averages and by expected values.

Group II Samples 10-2, 12-2, 14-2, and 21-2 appear to have lower concentrations than can normally be expected. As in Group I the differences between the average total dissolved solids and the expected dissolved solids applied to the total solids effluent values determined by the laboratory would bring all four samples within the parameters. Similar treatment to Sample 19-4 which has a higher than normal concentration would give like results.

It will be noted in Table 2 that total dissolved solids are substantially greater for Group II samples than for Group I, with its much greater dilution of sanitary wastes. The effect which this fact has on the effluent concentrations for total solids is offset somewhat by the lesser concentrations of total suspended solids effluent for Group II samples.

Settleable Solids

The normal range of concentrations of waste water in the O.S.I.S. for dry weather flow is estimated to be from 2.0 to 3.5 ml/l, and is based on the plotted relationship between the influent concentrations of settleable solids and of total suspended solids for the sampling periods for Storm 9 through 24. The linear relationship between the settleable solids and total suspended solids has a ratio of 1 to 100. Results of laboratory tests of samples for Storm 9 through 24 show a concentration as low as 0.1 ml/l and a maximum of 3.0 ml/l. The majority of the concentrations lie between 1.0 and 2.5 ml/l. The lowest influent concentration (Storm 16-2) occurred during the period having a low intensity rain prior to the sampling period. (See Figure 10). Furthermore, the composite was collected from late Saturday evening to early Sunday morning when dry weather flow concentrations were expected to be the lowest during the week. The highest influent concentration (Storm 18-2) was taken during a period of high intensity rainfall. (See Figure 11).

Figures 35 and 36 show the relationship of settleable solids influent concentrations to flow in the O.S.I.S. for Groups I and II, respectively, for all influent samples taken in Storms 9 through 24. The trend of concentration versus O.S.I.S. flow for Group I is much the same as that for Total Suspended Solids with decreasing concentration from the smaller flow to moderate flows and then increasing concentrations as the flow becomes greater. The parameters of the influent curve at a flow of 35 MGD was assumed to be 2.0 and 3.5 ml/l for both groups, decreasing to 0.6 ml/l at a flow of 60 MGD and retaining such parameters to the maximum flow pertinent to the Group. Only the results of two tests fell outside the parameters established for influent concentration for Group I samples, namely, 24-1 and 24-2. Sample 24-1 was obtained in the third 8-hour period on Sunday. The results of the test of this sample by the Columbus Water and Chemical Testing Laboratory were a concentration of 1.3 ml/l, very close to the lower parameter curve. The concentration for 24-2 appears to be low compared to the concentrations of the Total Suspended Solids. Generally, the concentrations were greater when the temperatures were under 15° C.

The influent concentration for Group II samples generally decreased with an increase in O.S.I.S. flow and the mean influent curve for Group I recedes into the similar curve for Group II as occurred for the Total Suspended Solids mean curve for Group II. For the same, or nearly the same, flow in the O.S.I.S. the concentrations are greater when the temperature is above 15° C. There are several tests results which fall outside the parameters (0.6 ml/l each side of the mean) established for Group II concentrations. The greatest departure from the mean curve is Sample 19-3 which has a concentration of 2.5 ml/l (average of State, and Columbus Water and Chemical Testing Laboratory results) or 1.4 ml/l greater than the mean value. The State value for this sample was 2.0 ml/l which would make it only 0.3 ml/l beyond the upper parameter. Similarly, for Sample 24-9 the average of the State and the Columbus Water and Chemical Testing Laboratory value is 2.35, or 1.15 ml/l greater than the mean value value, but the concentration determined by the latter laboratory was 1.9 ml/l or 0.4 ml/l outside the upper parameter. With respect to the Sample 22-2 average concentration, there is no apparent reason for its departure from the expected value (all three laboratories had very different results - 1.0 by State, 0.3 by the City and 0.6 by the Columbus Water and Chemical Testing Laboratory). Samples 12-2, 16-2, and 16-3 were all taken on Sundays when concentrations can be expected to be less but not to the extent shown. Other samples falling outside the parameters are 15-6, 15-8, and 24-5. Either an error in making or recording the results of those tests, or failure to obtain a truly representative sample for this test are possible causes for points falling out of line.

Effluent concentrations which can be expected for any flow in the O.S.I.S. with various magnitudes of flow bypassing the tanks are shown on Figures 39 and 40 for Groups I and II, respectively. Figure 39 shows that if no flow is bypassed, the expected effluent concentration for Group I would be 0.5 ml/l at a flow of 35 MGD in the O.S.I.S. and about 1.5 ml/l for a flow of 320 MGD with 100 MGD bypassing the tanks. Similar expected effluent concentration for various flows for different magnitude of flows bypassing the tanks can be determined from Figure 39. Several actual effluent values plot above the mean influent curve. Reference to Figures 35 and 36, curves for Groups I and II influent samples, show that all were at or outside the curve for the upper parameter. Table 2 indicates that only 7 expected effluent values differed by more than 0.4 ml/l from the actual test results; they were for samples 10-1 and 14-1 in Group I, and 10-2, 14-2, 15-6, 19-3, and 24-3 in Group II. The laboratory results for Samples 10-1, 15-6, 19-3, and 24-3 are not compatible with the concentrations for corresponding total suspended solids. Effluent concentration for Sample 14-1 is greater than the mean influent concentration. There is no apparent reason for the more than normal difference between the expected and actual concentrations for Samples 10-2 and 14-2.

Biochemical Oxygen Demand (B.O.D.)

As shown on Figure 41 the normal range of concentrations of waste water in the O.S.I.S. for dry weather flow ranges from 150 to 300 mg/l. For Storms 9 through 24, the range of concentrations for influent varies from 25 mg/l to 320 mgl. About 80 percent of the actual influent values were 70 mg/l or greater.

The relationship of B.O.D. influent concentration to magnitude of O.S.I.S. flows are shown on Figures 41 and 42 for Groups I and II samples, respectively. For Group I samples, concentration decreased with an increase in flow rapidly from low flows to moderate flows and then decreased slowly as the O.S.I.S. flow increased. The trend is the same for all samples regardless of the time of day the samples were taken. Lesser concentrations for comparable flows generally prevail when the temperatures are 15° C or more. The parameter limits for the plotted values are plus or minus 30 mg/l above the mean influent curve for Group I. Concentrations for seven samples (10-1, 11, 15-1, 15-2, 15-3, 15-4, and 24-1) fall outside of the parameters. Values of concentration for B.O.D. tests in Storm 15 have not been used in establishing the parameter, because seven of nine periods in the Storm (Groups I and II) are not in the range to be expected for the pertinent flows. The concentration for Sample 10-1 is far greater than can be expected, and Sample 11 has a concentration somewhat higher than would be expected. Either the samples tested were not representative or errors were made in the laboratory testing and/or recording. The low value for 24-1 may be due in part to the fact that it was for the evening period on Sunday when concentrations are lower.

Influent concentrations for Group II samples decrease rapidly with an increase in O.S.I.S. flow. The parameter limits are the same as for Group I. The transition between Group I and Group II mean curves is between flows of 150 and 250 MGD. The concentrations for samples taken between midnight and 8 A.M. in seven of eight samples were less than the values shown on the mean influent curve for Group II. In most instances concentrations are greater when the temperature of the waste water is under 15° C. Concentrations for five samples fall outside of the parameters established, namely, 14-2, 14-4, 24-5, 24-8, and 24-10. The concentration of 320 mg/l for Sample 14-4 is believed to be twice its actual value and probably results from a mathematical error. A similar statement could be applied to Sample 24-8 which appears to be half its expected value because Sample 24-9 with a lesser flow had a concentration of 111 mg/l. Likewise, Sample 24-10 whould have a concentration of one-half of the laboratory value to be in line with 24-9, the preceding sample. Others falling outside the parameters were samples taken between midnight and 8 A.M. when concentrations are lower.

Curves for effluent concentration to be expected for varying flows in the O.S.I.S. at different quantities of flows being bypassed around the tanks are shown on Figure 45 and 46 for Groups I and II samples, respectively. The effluent curves have the same general trend as the influent curves for the corresponding group. All of the effluent curves represent mean values for the magnitude of bypass indicated. Based on the parameters for influent concentration, samples having actual effluent concentration approaching 30 ± mg/l of the expected values would be considered as conforming to the expected concentration. Table 2 indicates that three samples (11, 12-1, and 14-1) fall outside of the established parameters for Group I samples; and six samples (10-2, 14-2, 18-5, 19-2, 24-8, and 24-10) are outside of the parameters for Group II, exclusive of periods in Storm 15.

In Group I all exceptions have effluent values greater than the mean influent values. Moreover, two of the three samples had effluent concentrations greater than the corresponding influent concentrations (11 and 14-1). Again it appears that faulty sampling procedures or poor laboratory work was the cause of such results, because in the case of Sample 11 there was a detention time of 74 minutes for a flow of 73 MGD through the tanks.

Only one sample (18-5) in Group II had an effluent concentration greater than that for the influent. Sample 24-10 as plotted and shown on Table 2 represents the average of two values and has an effluent value of 151 mg/l; the State concentrations for the influent and effluent are 153 and 132 mg/l, respectively. Both effluent values appear to be too high. Two samples (19-2 and 24-8) had effluent concentrations (21 and 16 mg/l) much lower than could be expected. The other two samples (10-2 and 14-2) have effluent values which appear high considering the long detention times involved (174 and 62 minutes).

Dissolved Oxygen

A preliminary review of the data on dissolved oxygen points out clearly that the magnitude of flow in the O.S.I.S. and the temperature of the waste water are the most important factors in determing the concentration (or percent saturated) of dissolved oxygen for influent. As the flow increases and the temperature of the waste water decreases, the quality of the dissolved oxygen improves. The principal factors in the improvement of effluent are the influent concentration (or percent saturation) of dissolved oxygen, the temperature, and the magnitude of flow passing through the tanks. The turbulence of flow in the outlet channel resulting from flows passing over the tank weirs is believed to provide the major aeration for the waste water, and, therefore, is considered to be an important factor in the improvement of the effluent quality of dissolved oxygen. It will be noted from Tables 3A and 3B that the percentage of improvement in dissolved oxygen is very considerable for those periods having extended detention times. However, the extent to which the detention time should be credited for the improvement is problematical, because long detention periods occur at low flow periods when the dissolved oxygen concentration of the influent is low and tendency for improvement is greater.

In analyzing the data, it was considered advisable to segregate samples into two groups based on temperature rather than being based strictly on flow conditions as was done for all the preceding analyses. One group ("A") would contain all samples having temperatures of less than 15° Centigrade and the other group ("B") would contain all samples having temperatures greater than 15° C. In plotting the value of each sample, the samples designated Group I for other analyses are differentiated from those for Group II by symbol (see Figures 47 to 51 inclusive). The value for each sample is the average of the values for all individual samples in an 8-hour period. Relationships were established for each group between percent saturation of dissolved oxygen and flow in the O.S.I.S. and also between the percent saturation of dissolved oxygen of the influent and the percent improvement of dissolved oxygen. The mean curves developed for these two relationships were used as described later to determine the percent saturation of dissolved oxygen of the effluent to be expected. Percent saturation of dissolved oxygen was used instead of dissolved oxygen in mg/l because percent saturation takes into account the temperature effect. Also, better curves for mean influent and effluent were developed using percent saturation.

It will be noted in Figures 47 and 48 that the percent saturation of dissolved oxygen of the influent increases rapidly as the flow in the O.S.I.S. increases to a rate of approximately 180 MGD when the temperature of the waste water is below 15° C and at a more constant rate for temperatures higher than 15° C. The general cycle for storms having several 8-hour periods is for the percent saturation of dissolved oxygen to increase to a peak at or shortly after the initial peak flow and remain high for the next period or two even though the magnitude of flow in the O.S.I.S. drops off and thereafter becomes less with a further decrease in the flow. When secondary peaks occur, such as 15-4 and 24-7, greater percents of saturation of dissolved oxygen are again experienced. Most of the actual values plot relatively close to the mean influent curves.

In order to relate effluent values to O.S.I.S. flows a curve was developed showing the relationship of the percent saturation of dissolved oxygen of the influent to the percent improvement of the percent saturation of dissolved oxygen. The plotted points represent the actual laboratory results and the curve the mean expected improvement. (See Figure 49).

Mean effluent curves of expected values were then developed using the percent improvement pertinent to the percent saturation of dissolved oxygen and adding it to the mean influent curve values (Figures 47 and 48) for the appropriate percent saturation of dissolved oxygen to establish effluent curves. For example, as shown on Figure 49, the mean percent improvement expected for influent having a percent saturation of dissolved oxygen of 45 percent is 30 percent. Figure 47 shows that the mean influent curves for such saturation occur at flows of 121 and 82 MGD, respectively, for the ascending and receding curves. Points for both effluent curves are plotted having values of 58.5 (45 + 30% of 45) percent saturation for the ascending and receding curves. The expected mean improvement in percent saturation of dissolved oxygen ranges from 8 percent at 70 percent saturation to 200 percent at 10 percent saturation. Laboratory tests showed a range in improvement of 1100 percent at a 3 percent saturation down to 4 percent with an influent having a 63 percent saturation.

Ether Solubles

Reference to Appendix A, particularly to those pages pertinent to Storms 18 through 24 when tests were being made by two or three laboratories, indicates that for the majority of sample periods the results of the laboratory tests were not in agreement either for influent or effluent concentrations. During those storms, concentrations of influent samples varied from 8 to 85 mg/l for the Columbus Water and Chemical Testing Laboratory tests, 0.8 to 47 mg/l for the State tests, and 12 to 54 mg/l for the City tests and effluent concentration variations were from 5 to 92, 2 to 50, and 8 to 32 mg/l, respectively, for the three laboratories. It appears that no patterns comparable to those developed for other tests could be developed.

Quality of Scioto River Flow

During the study, samples of Scioto River flow were obtained and tested by the City of Columbus upstream and downstream of the Whittier Street Tanks. Seven samples were taken during periods when sampling was being done for O.S.I.S. flows being passed through the tanks. Only dissolved oxygen tests were made of the river flow. When the flow was lowest in the river (280 MGD), the percent saturation of dissolved oxygen was 107 at Mound Street (upstream), 115 at Frank Road (downstream), and 45 for the effluent from the tanks. The flow in the O.S.I.S. at that time was 84 MGD. The discharge of a significant amount of waste water with a lower percent saturation of dissolved oxygen into the river at the Whittier Street Tanks was apparently offset by an increase in percent saturation in the river flow resulting from aeration of the stream flow in its passage over the Greenlawn Dam (about a 7½ foot drop).

WHITTIER STREET STORM STANDBY TANKS

DISSOLVED OXYGEN DATA

GROUP A (Temperature less than 15° C)

Storm No.	Total O.S.I.S. Flow MGD	Detention Time Min.	Temperature °C	Dissolved Oxygen		Dissolved Oxygen Saturation					
				Infl. mg/l	Effl. mg/l	Influent		Effluent		Improvement	
						Act. %	Exp. %	Act. %	Exp. %	Act. %	Exp. %
11	101	74	11.5	5.5	7.0	50	35.5	62.5	53	25	51
12-1	136	56	10.6	5.5	6.3	48.5	49	56	61	15	24
12-2	70	174	13.2	2.9	5.2	27	36	48	53	77	50
13	151	38	9.1	6.2	7.7	53	52	66	63	24	21
14-1	203	28	8.3	7.3	8.4	62	59	71	67.5	15	14
14-2	115	62	10.0	7.6	8.1	67	57.5	71	67	6	20
14-3	79	82	12.0	5.1	5.8	47	43	53.5	57	14	34
14-4	59	216	13.0	4.2	5.9	39	22	55	45	40	105
15-1	110	76	10.3	4.8	6.9	42	40	60	55.5	42	40
15-2	385	17	9.9	6.4	7.5	55.5	65	65	71.5	17	10.5
15-3	161	61	11.6	5.3	7.3	48	54	65.5	64	36	19
15-4	287	28	10.9	7.4	8.0	67	65	72	71.5	8	10.5
15-5	212	27	11.0	7.5	8.3	68	65	75	71.5	11	10.5
15-6	227	25	11.6	8.1	8.7	74	65	79.5	71.5	7	10.5
15-7	192	30	12.0	6.6	7.1	61	65	65.5	71.5	8	10.5
15-8	142	41	12.0	6.6	7.8	60.5	62.5	72	70.5	19	12
15-9	134	44	12.6	6.2	7.9	58	61	73	70	26	13
16-1	200	28	9.1	6.7	7.3	58	59	63.5	67.5	9	14
16-2	108	55	10.7	6.9	8.1	61.5	55	70	65	14	18
16-3	99	62	11.6	5.9	7.1	54	52	65	63	20	21
17	105	98	12.4	3.9	6.5	37.5	37.5	59	54	57	46
18-2	383	30	13.9	5.7	6.9	55	65	66.5	71.5	21	10.5
18-3	139	42	13.9	6.2	7.4	59.5	62	71.5	70	20	12
18-4	135	48	13.9	6.6	6.8	63	61.5	65.5	70	4	12.5
18-5	114	55	14.1	5.3	6.4	50.5	57	62	66.5	23	16

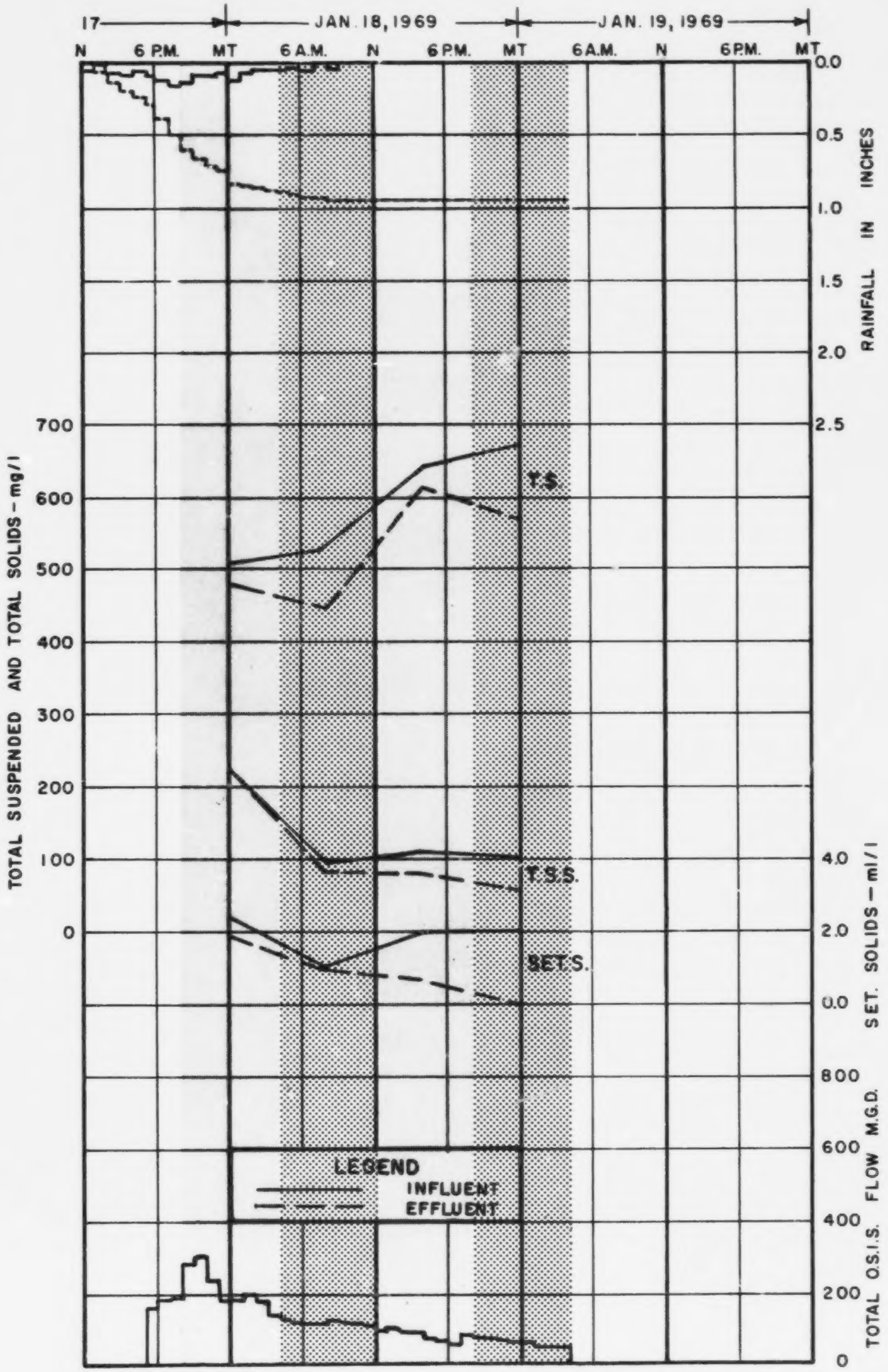
WHITTIER STREET STORM STANDBY TANKS

DISSOLVED OXYGEN DATA

GROUP 2 (Temperature greater than 15° C)

Storm No.	Total O.S.I.S. Flow MGD	Detention Time Min.	Temperature °C	Dissolved Oxygen Infl. mg/l	Dissolved Oxygen Effl. mg/l	Dissolved Oxygen Saturation Influent Act. %	Influent Exp. %	Effluent Act. %	Effluent Exp. %	Improvement Act. %	Improvement Exp. %
9	104	74	16.1	2.0	4.1	19.5	11	41.5	31	114	190
10-1	109	55	15.1	4.0	5.8	39.5	39	56	54	42	42
10-2	81	174	17.0	1.6	2.3	16	13	23.5	35	47	170
18-1	208	31	16.3	3.4	5.1	34	30	50.5	50.5	49	68
19-1	361	19	17.9	3.7	5.0	38.5	46.5	52	60	35	28
19-2	131	49	16.6	5.1	6.3	52	47	64	59	23	27
19-3	126	47	17.3	3.9	5.4	40	45.5	55.5	58.5	39	30
19-4	114	58	17.1	3.9	5.0	40	41	51	55.5	28	38
20	210	27	17.8	4.3	5.5	44.5	50	57.5	61.5	29	23
21-1	107	80	19.7	0.6	3.3	6	12	35.5	32.5	485	180
21-2	85	117	19.0	2.1	4.5	22	15	48	40	120	150
22-1	135	58	18.5	2.1	4.4	21.5	17.5	45.5	40.5	112	135
22-2	64	225	20.6	0.3	3.2	3	5	35	18	1100	260
23-1	225	38	20.9	2.1	3.5	23.5	32	38.5	52	65	61
23-2	215	69	20.1	4.3	5.8	47	50	64	61.5	37	23
23-3	87	70	21.2	0.9	3.0	10.5	16	33.5	42	225	145
24-1	136	49	21.3	0.8	3.0	8.5	17.5	35	40.5	318	135
24-2	395	32	19.6	5.0	6.1	53.5	50	65.5	61.5	22	23
24-3	160	36	19.6	4.9	5.9	53	50	64	61.5	21	23
24-4	208	31	21.1	4.6	5.4	51	50	59	61.5	16	23
24-5	100	68	19.6	4.1	5.3	44	32.5	57	51	30	60
24-7	367	25	21.1	4.6	5.7	54	50	63	61.5	17	23
24-8	137	44	19.1	5.2	6.2	55	48	66	60	20	26
24-9	110	71	20.2	3.6	4.6	39	39	50.5	54	30	42
24-10	90	115	20.9	1.9	2.7	21	20	30.5	44	46	116

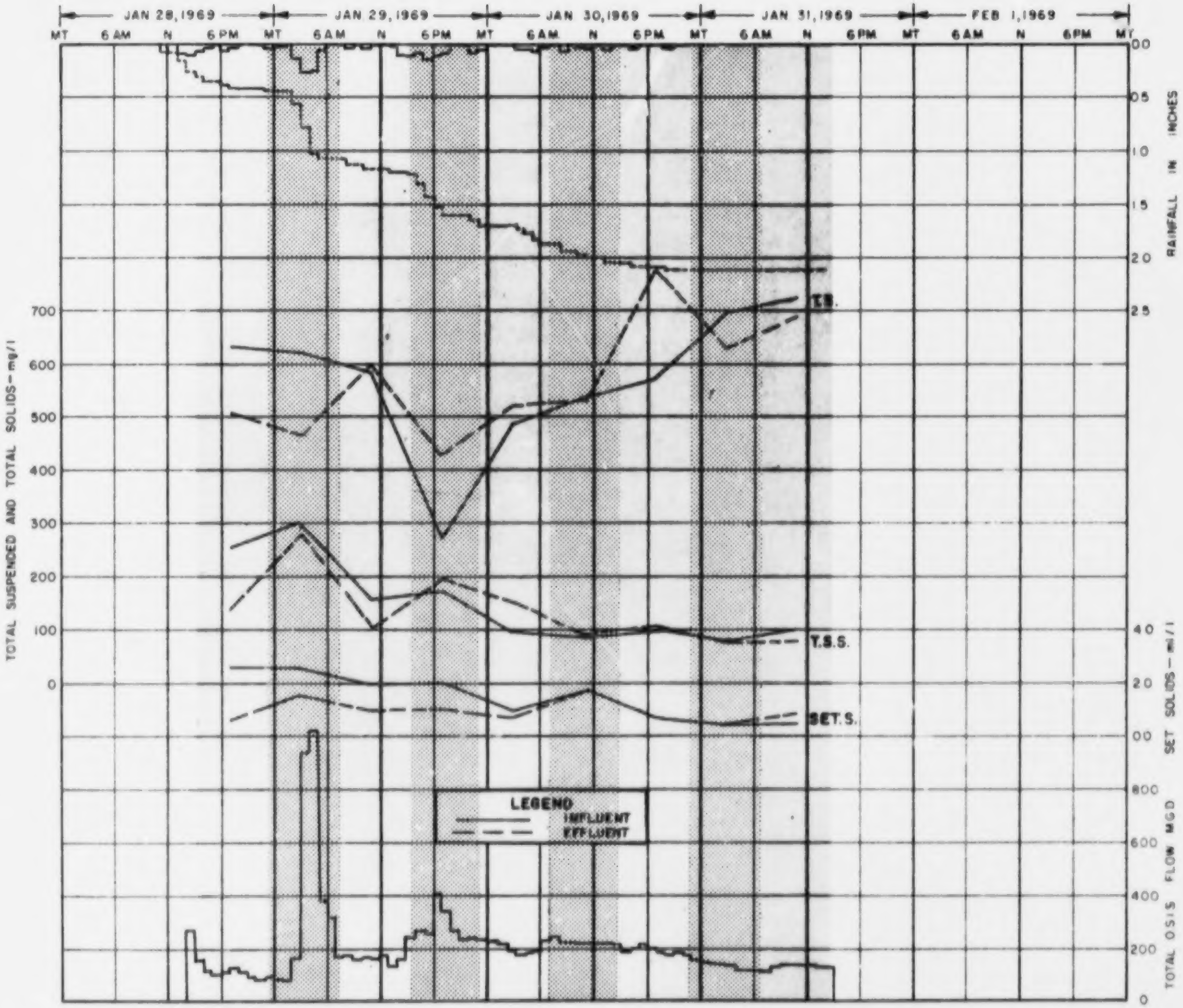
Table 3B



HYDROLOGICAL RELATIONSHIPS
TO CONCENTRATIONS OF SOLIDS

FIGURE 8

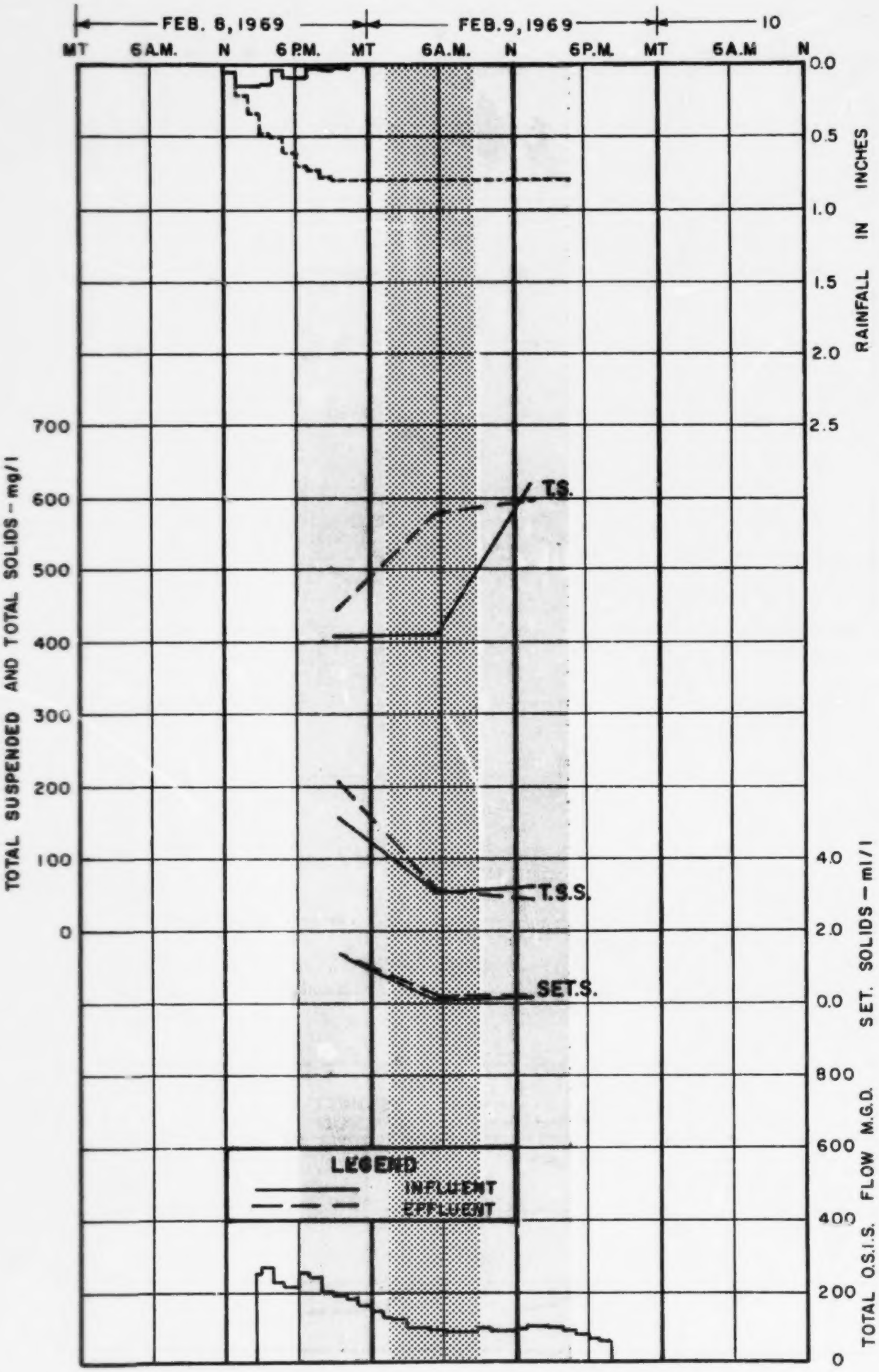
STORM 14



HYDROLOGICAL RELATIONSHIPS TO CONCENTRATIONS OF SOLIDS

FIGURE 9

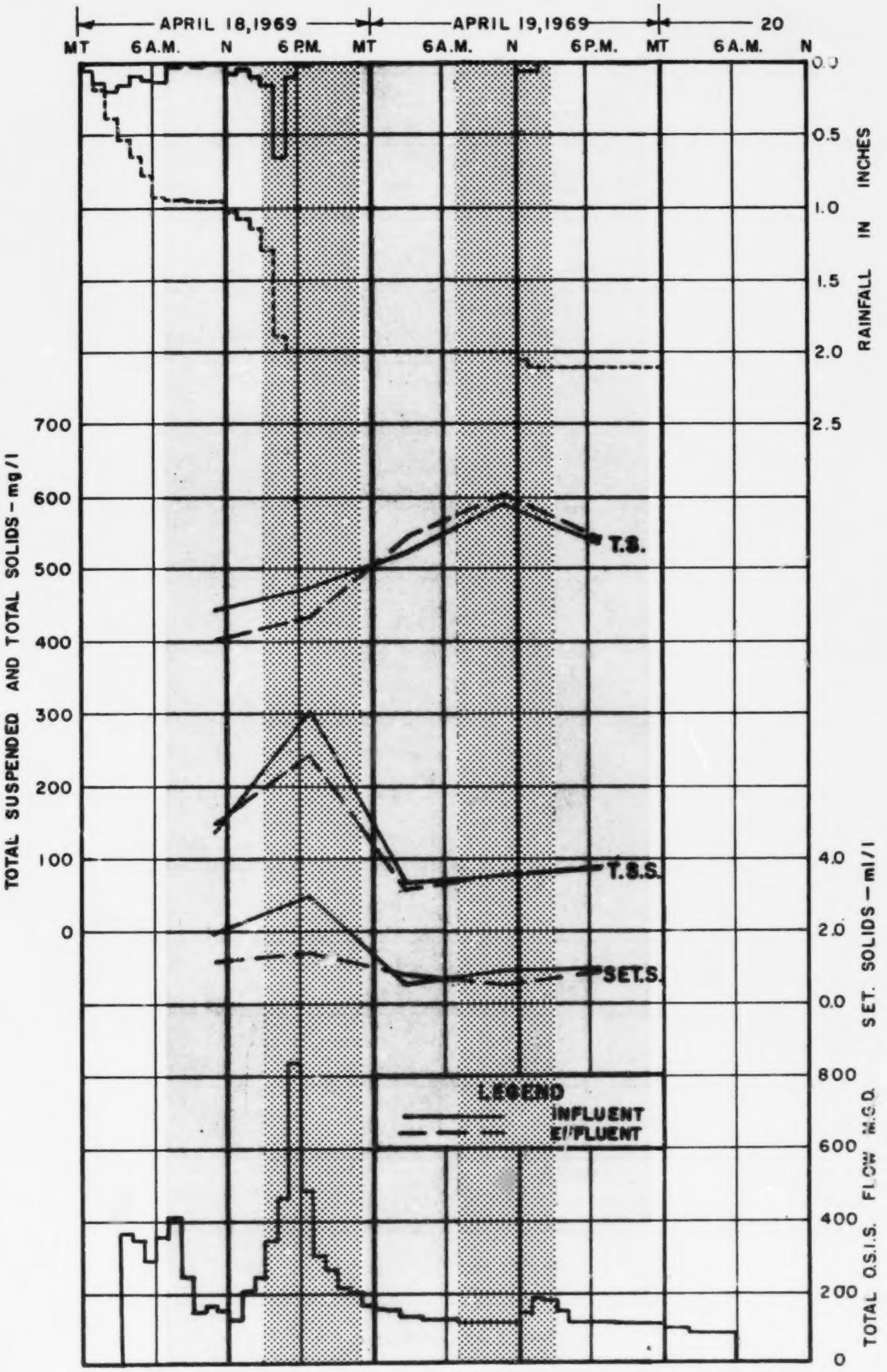
STORM 15



HYDROLOGICAL RELATIONSHIPS
TO CONCENTRATIONS OF SOLIDS

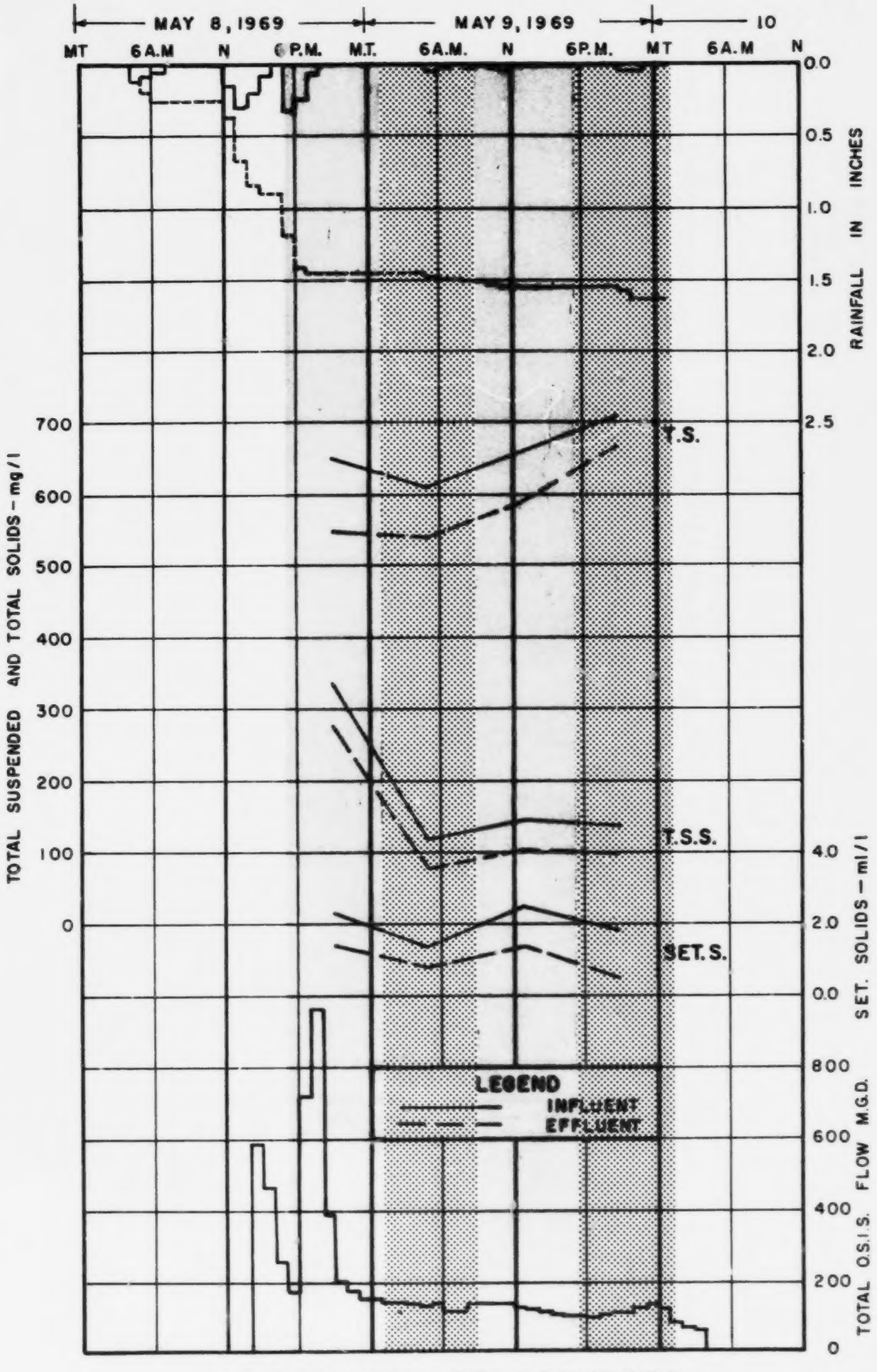
FIGURE 10

STORM 16



HYDROLOGICAL RELATIONSHIPS TO CONCENTRATIONS OF SOLIDS

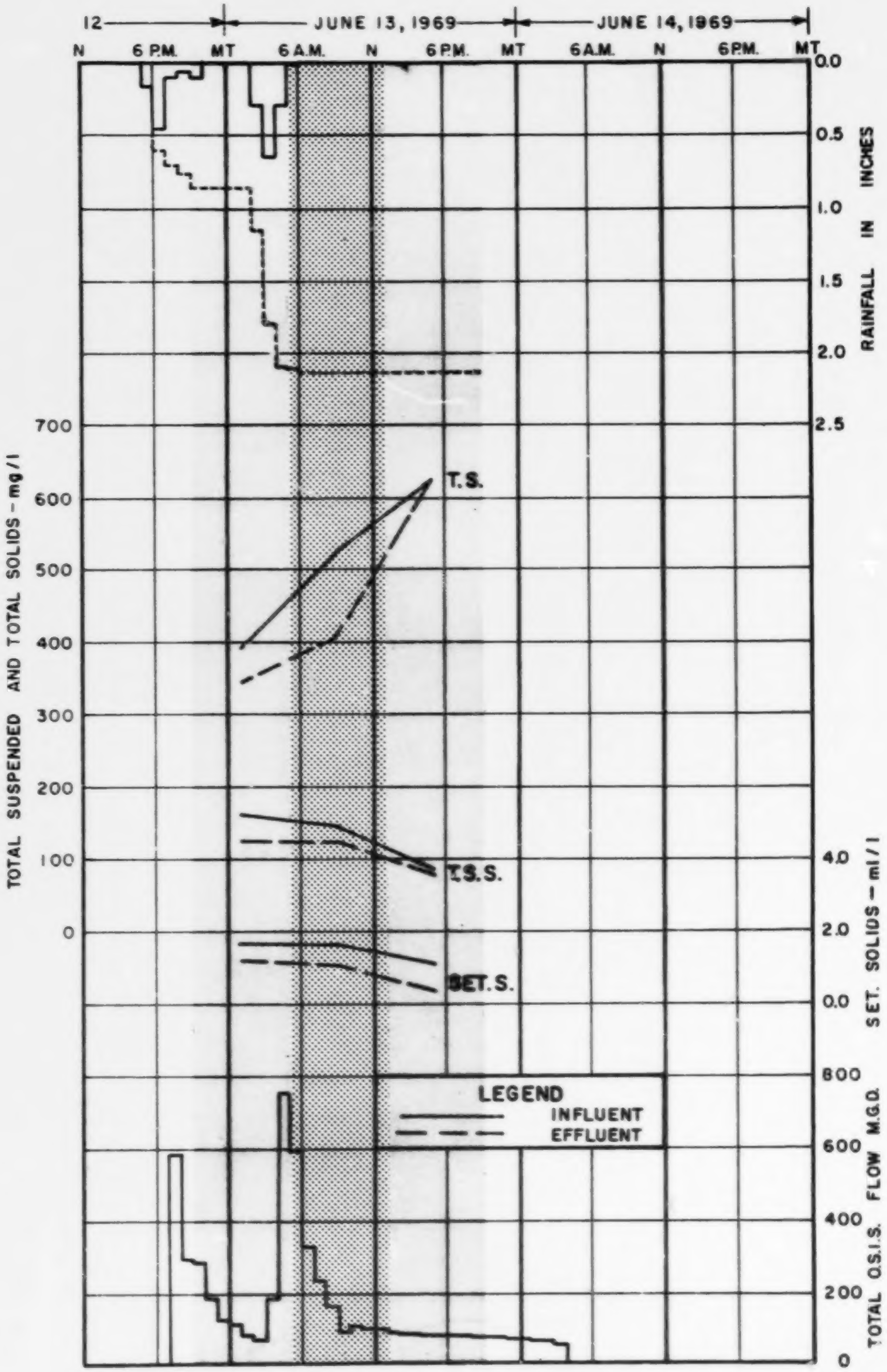
FIGURE 11 STORM 18



HYDROLOGICAL RELATIONSHIPS
TO CONCENTRATIONS OF SOLIDS

FIGURE 12

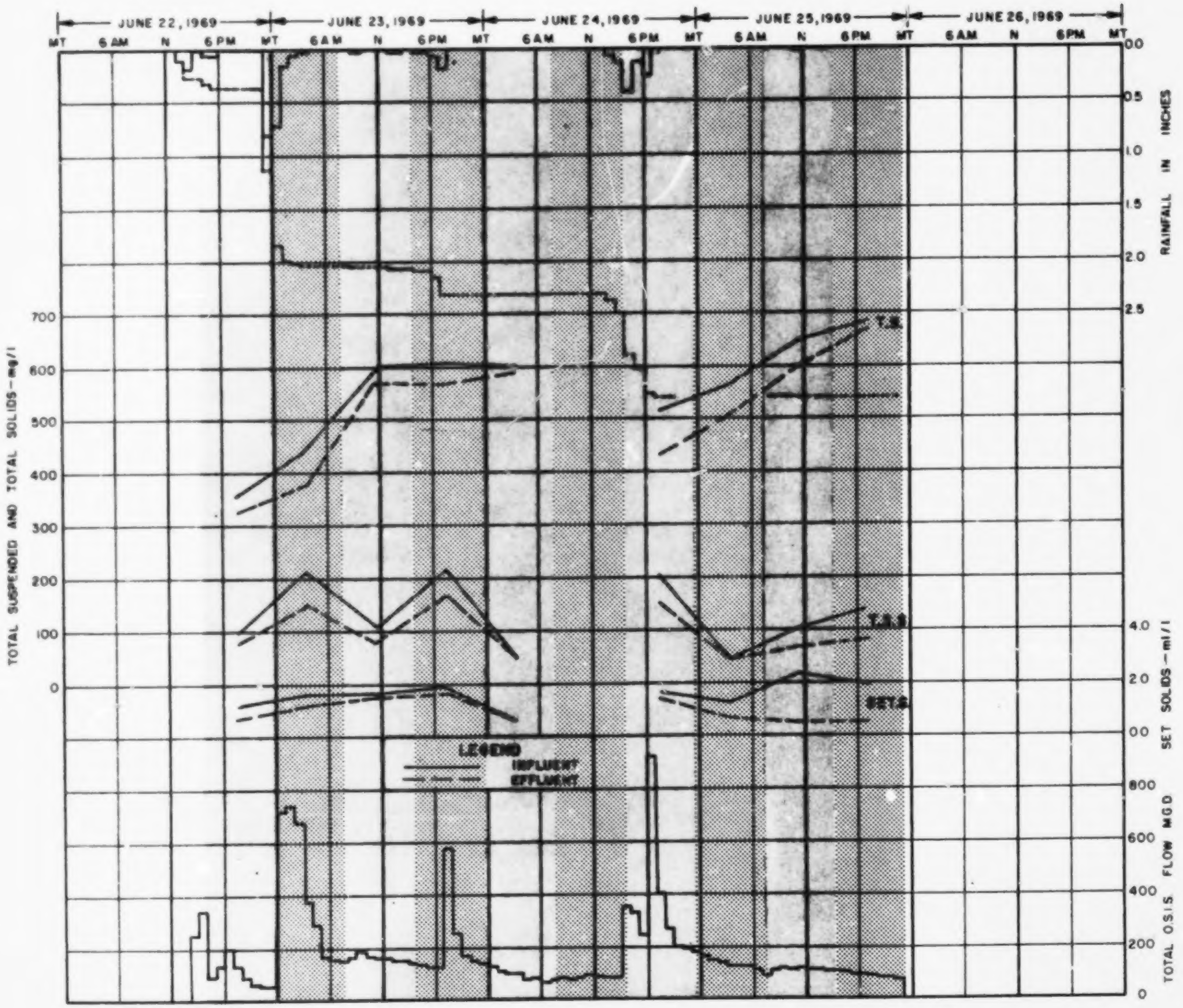
STORM 19



HYDROLOGICAL RELATIONSHIPS TO CONCENTRATIONS OF SOLIDS

FIGURE 13

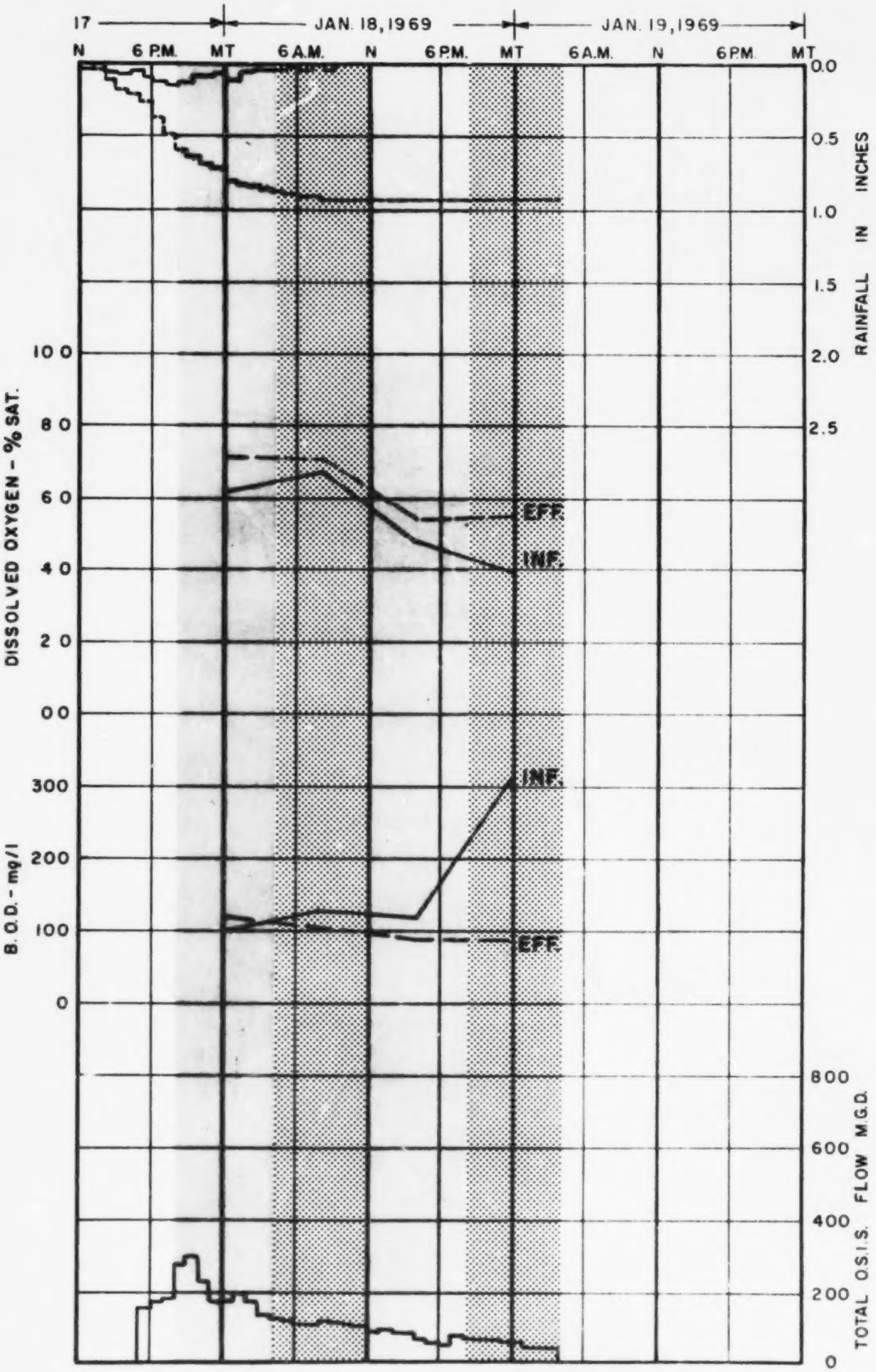
STORM 23



HYDROLOGICAL RELATIONSHIPS TO CONCENTRATIONS OF SOLIDS

FIGURE 14

STORM 24



HYDROLOGICAL RELATIONSHIPS
TO B.O.D. & DISSOLVED OXYGEN

FIGURE 15

STORM 14

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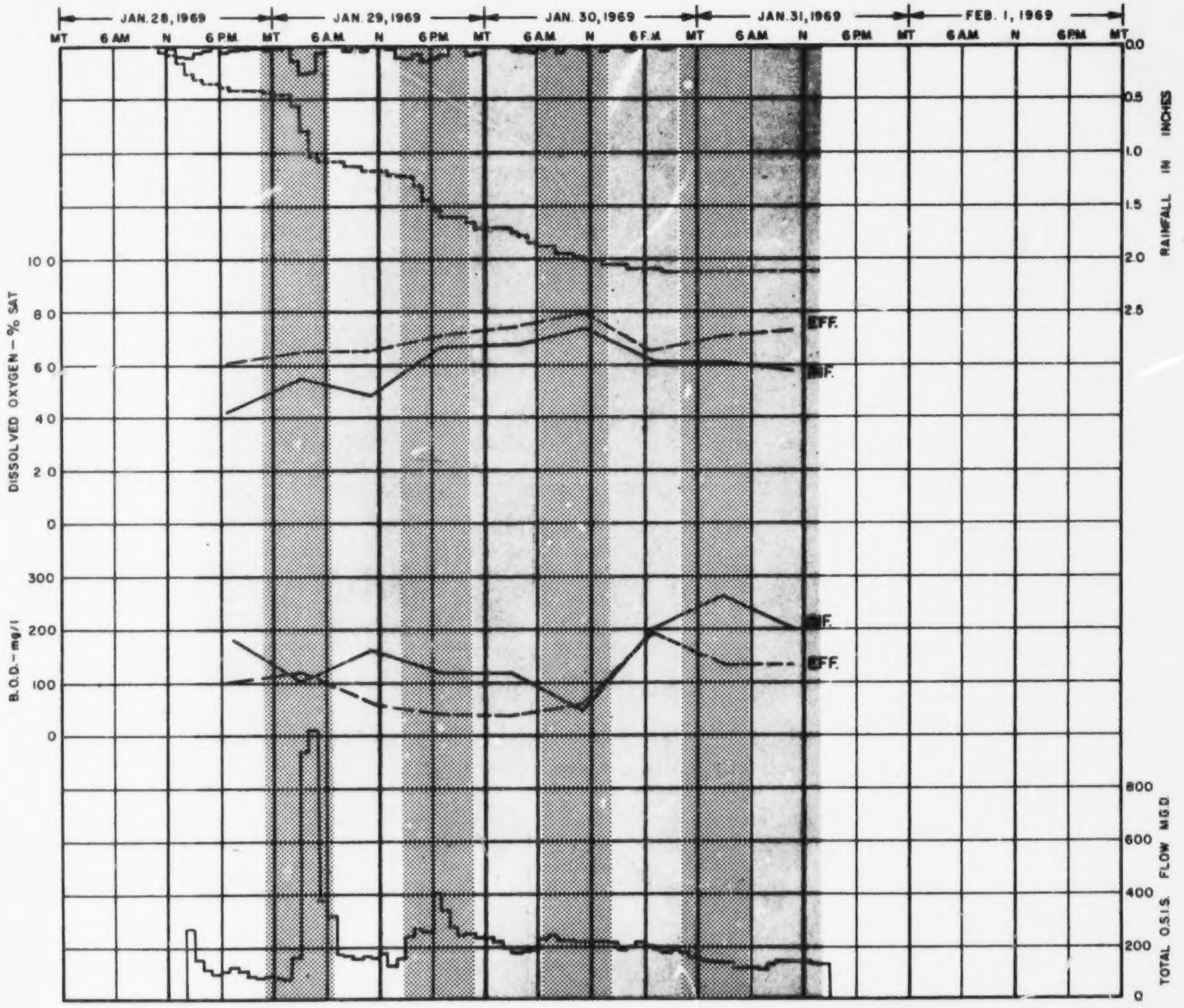
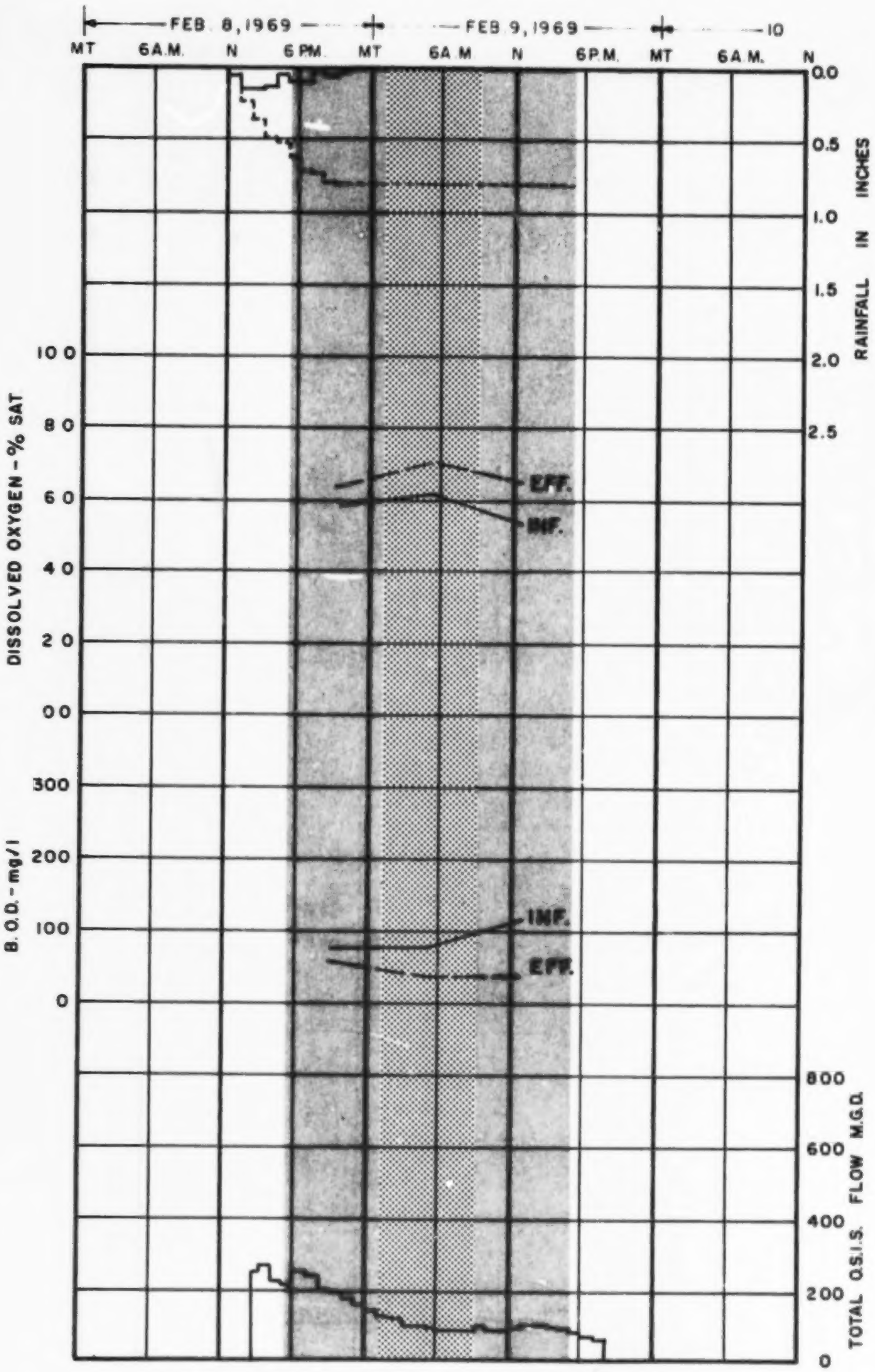


HYDROLOGICAL RELATIONSHIPS TO B.O D & DISSOLVED OXYGEN

FIGURE 16

STORM 15



HYDROLOGICAL RELATIONSHIPS
TO B.O.D. & DISSOLVED OXYGEN

FIGURE 17

STORM 16

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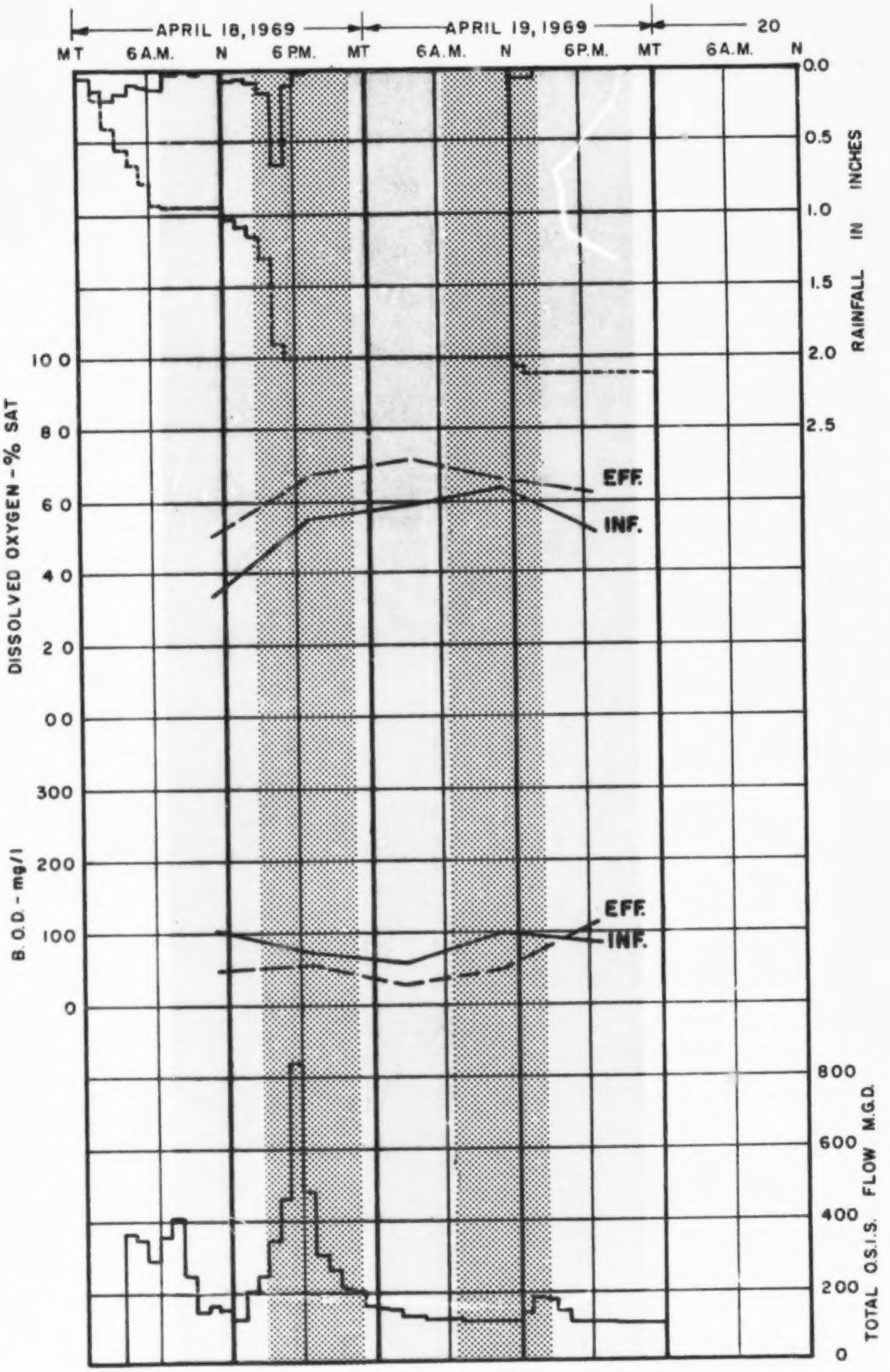
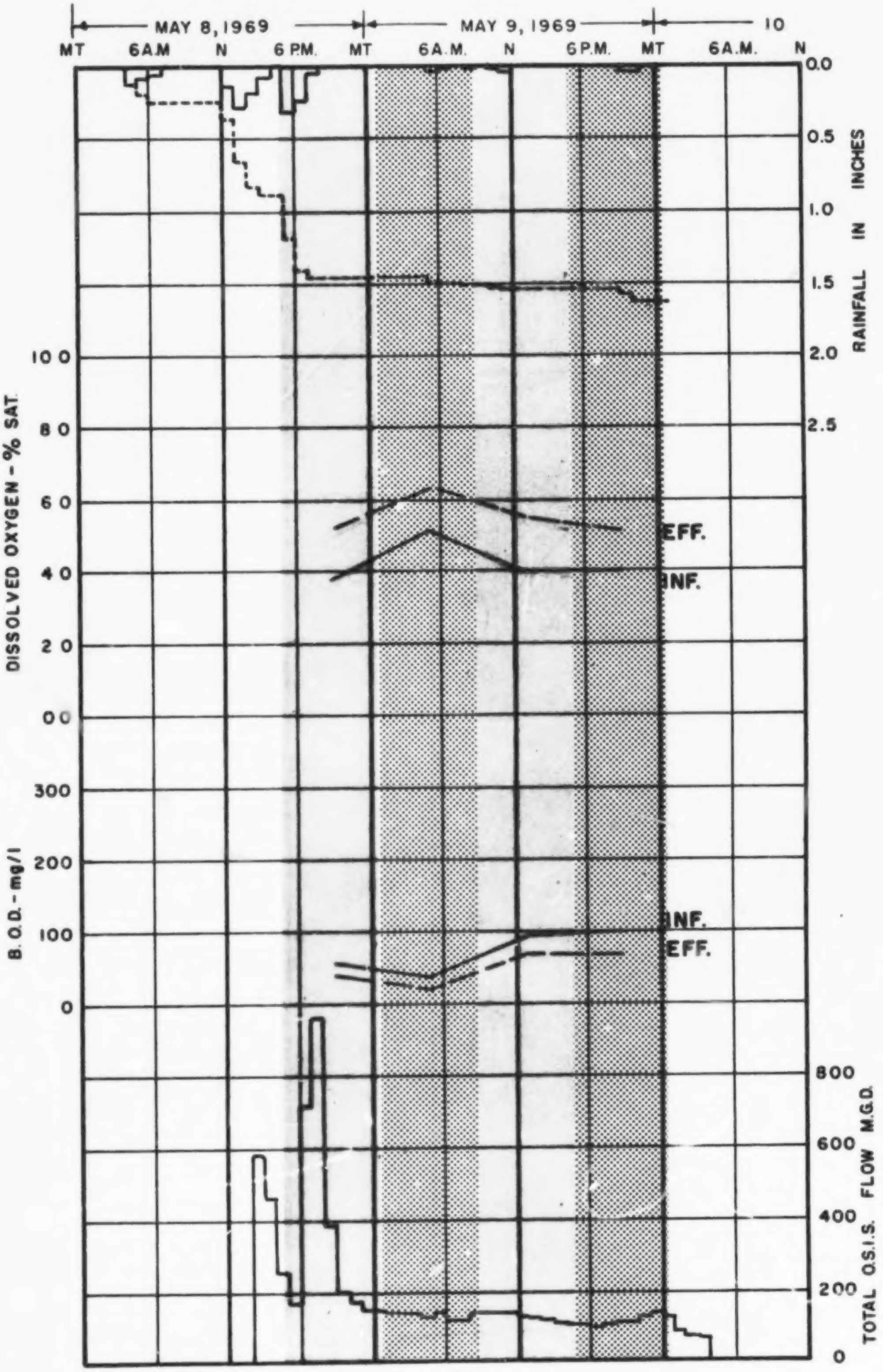


HYDROLOGICAL RELATIONSHIPS
TO B.O.D. & DISSOLVED OXYGEN

FIGURE 18

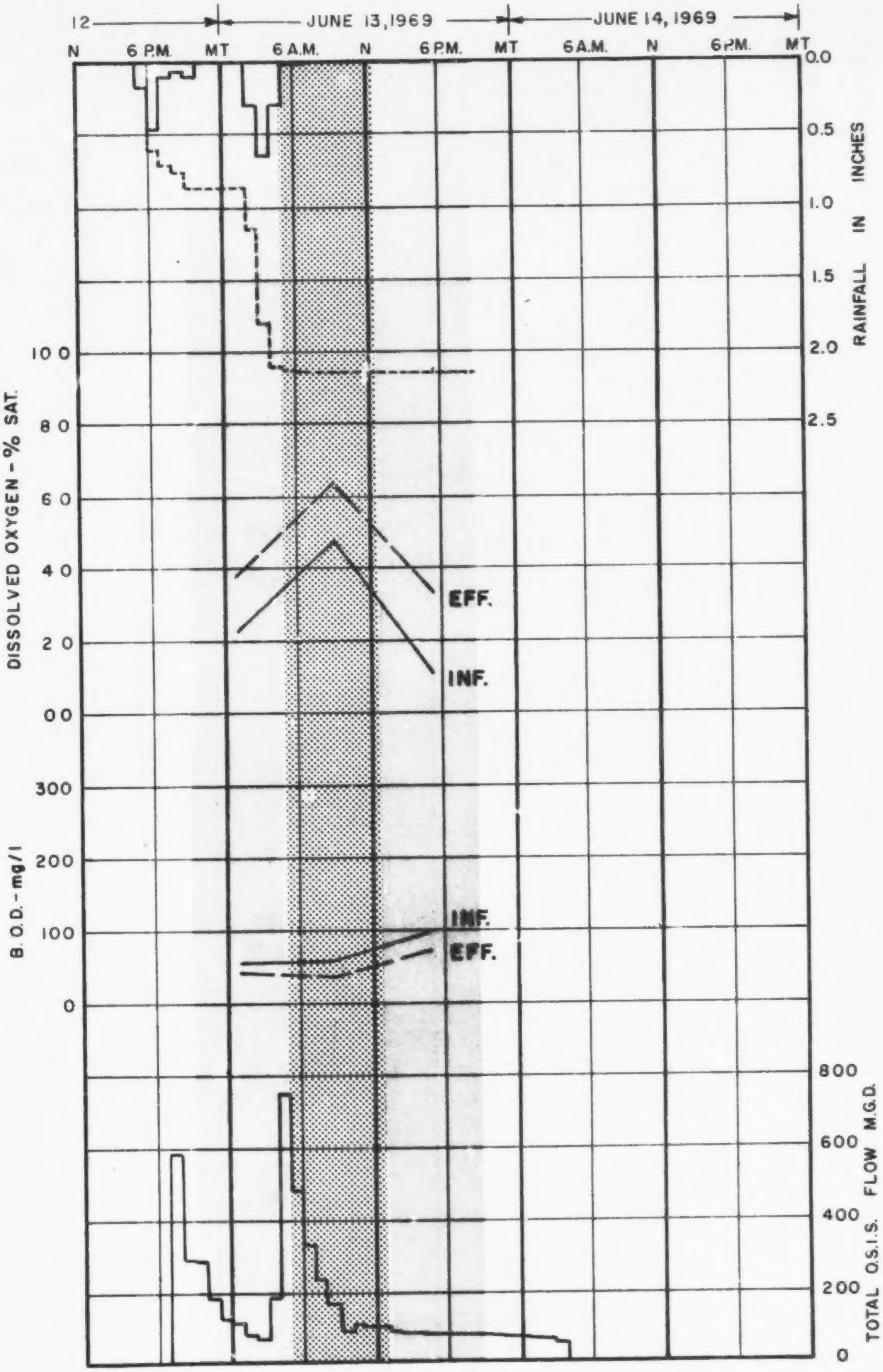
STORM 18



HYDROLOGICAL RELATIONSHIPS
TO B.O.D. & DISSOLVED OXYGEN

FIGURE 19

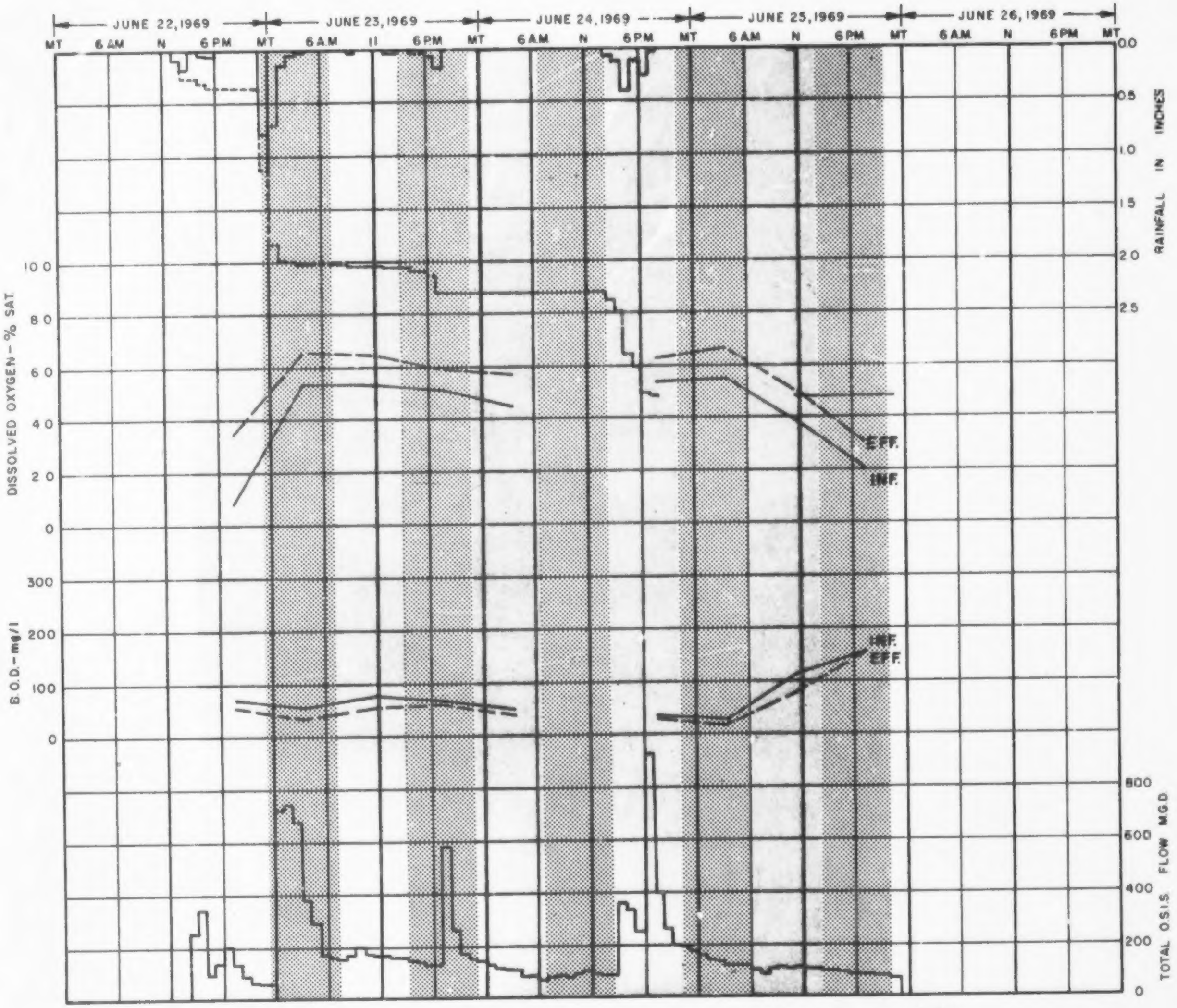
STORM 19



HYDROLOGICAL RELATIONSHIPS TO B.O.D. & DISSOLVED OXYGEN

FIGURE 20

STORM 23



HYDROLOGICAL RELATIONSHIPS TO B.O.D. & DISSOLVED OXYGEN

FIGURE 21

STORM 24

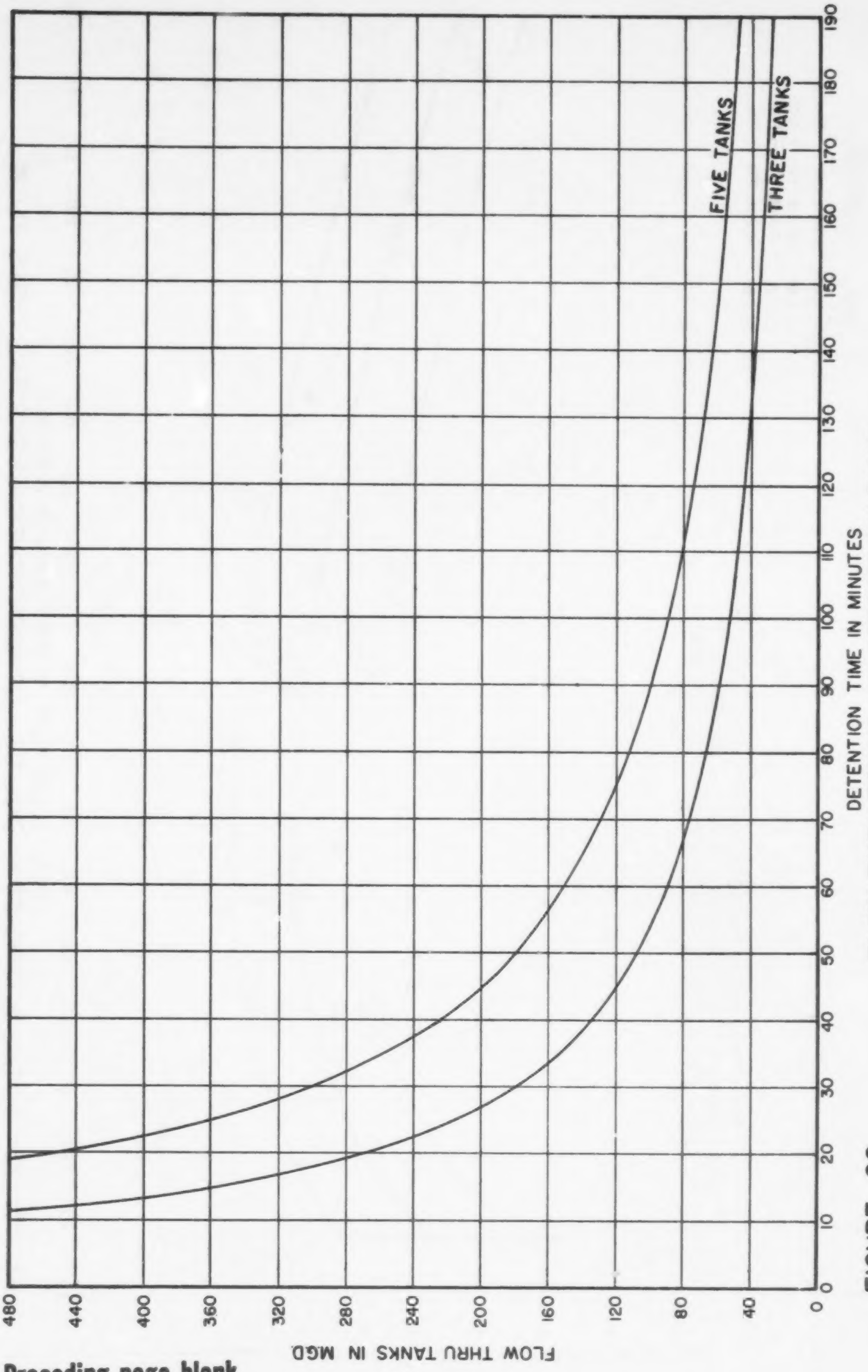


FIGURE 22

FLOW THRU TANKS VS. DETENTION TIME

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GROUP I INFLUENT SAMPLES

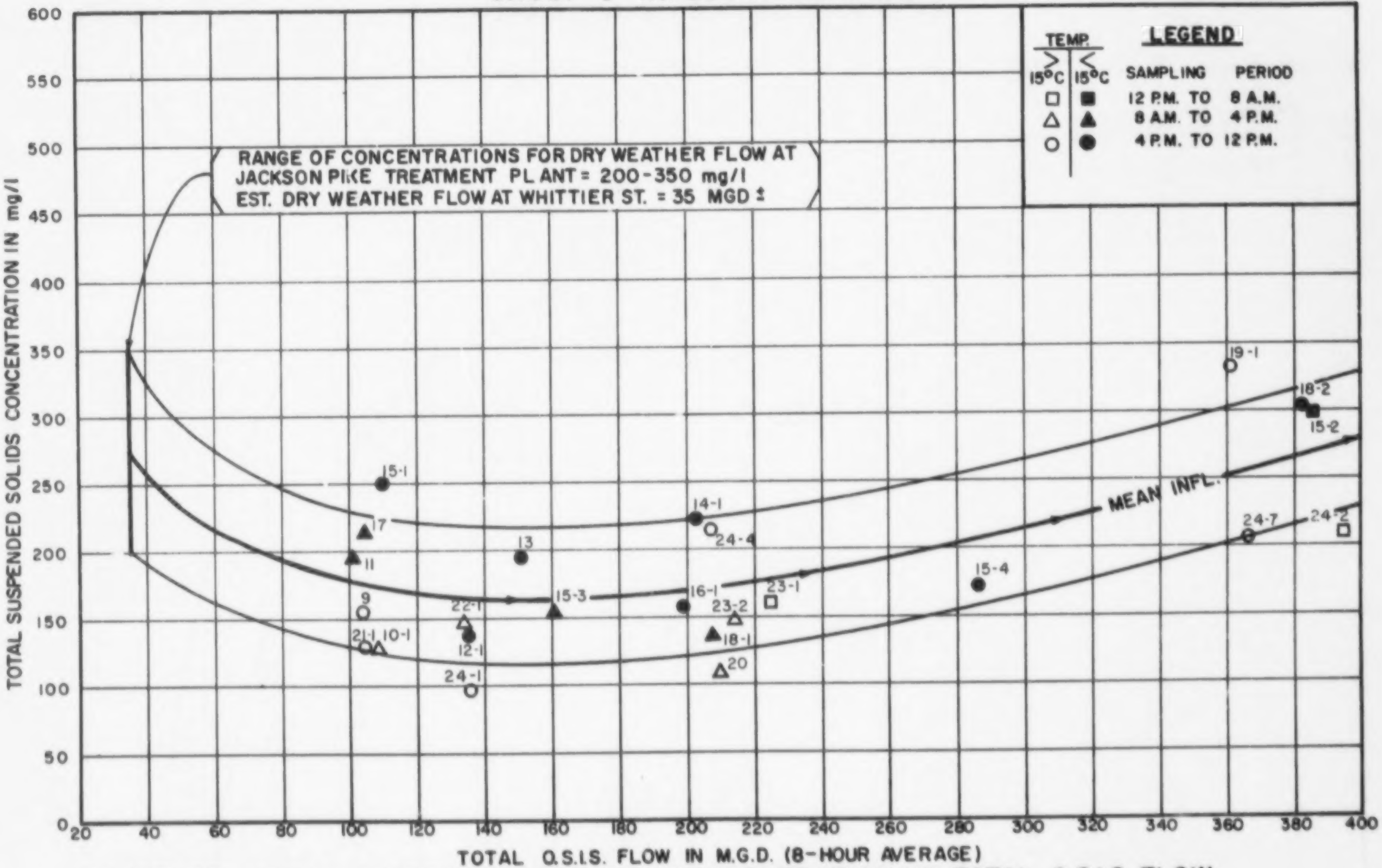


FIGURE 23 TOTAL SUSPENDED SOLIDS CONCENTRATION VS. TOTAL O.S.I.S. FLOW

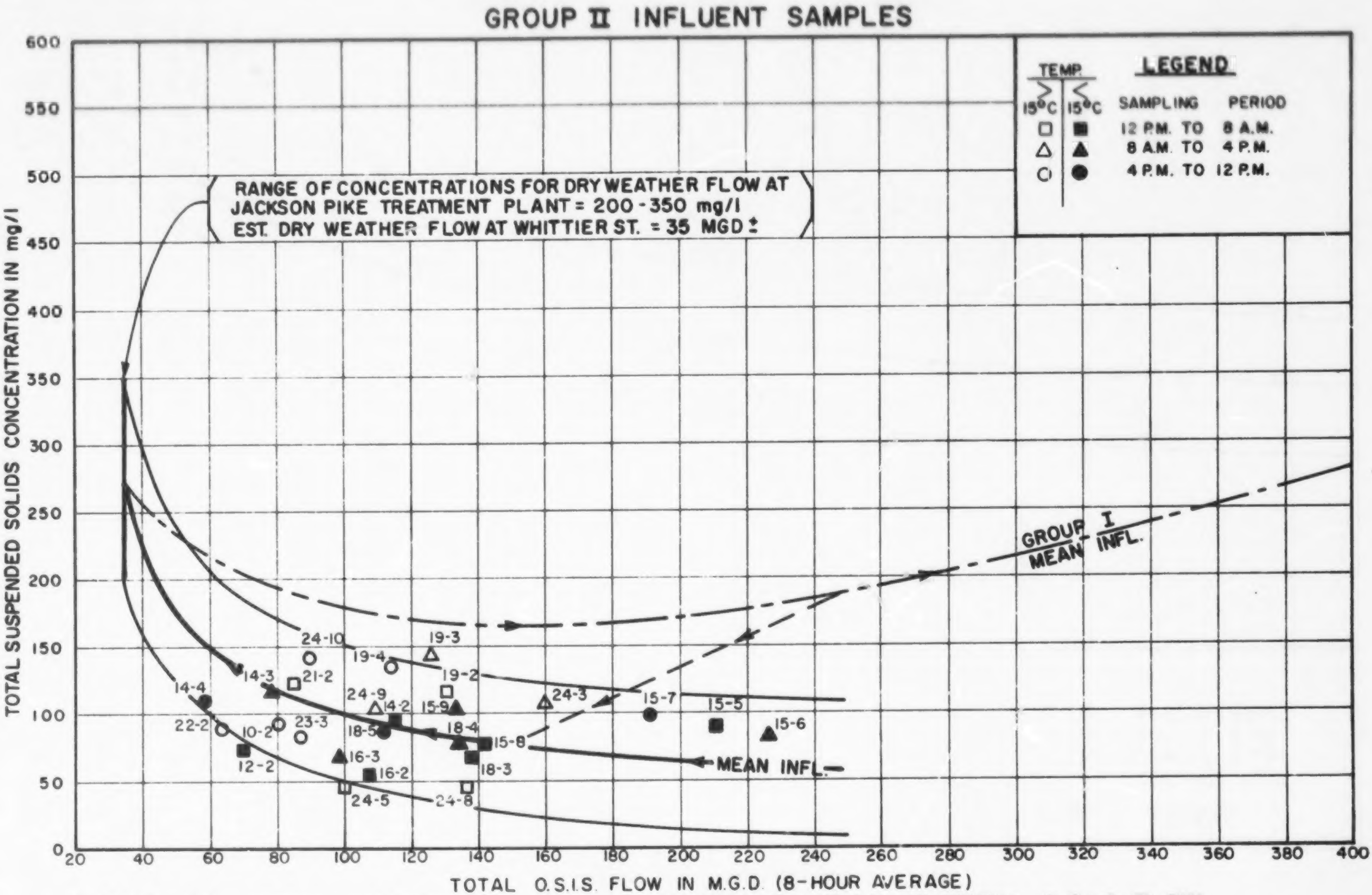


FIGURE 24 TOTAL SUSPENDED SOLIDS CONCENTRATION VS. TOTAL O.S.I.S. FLOW

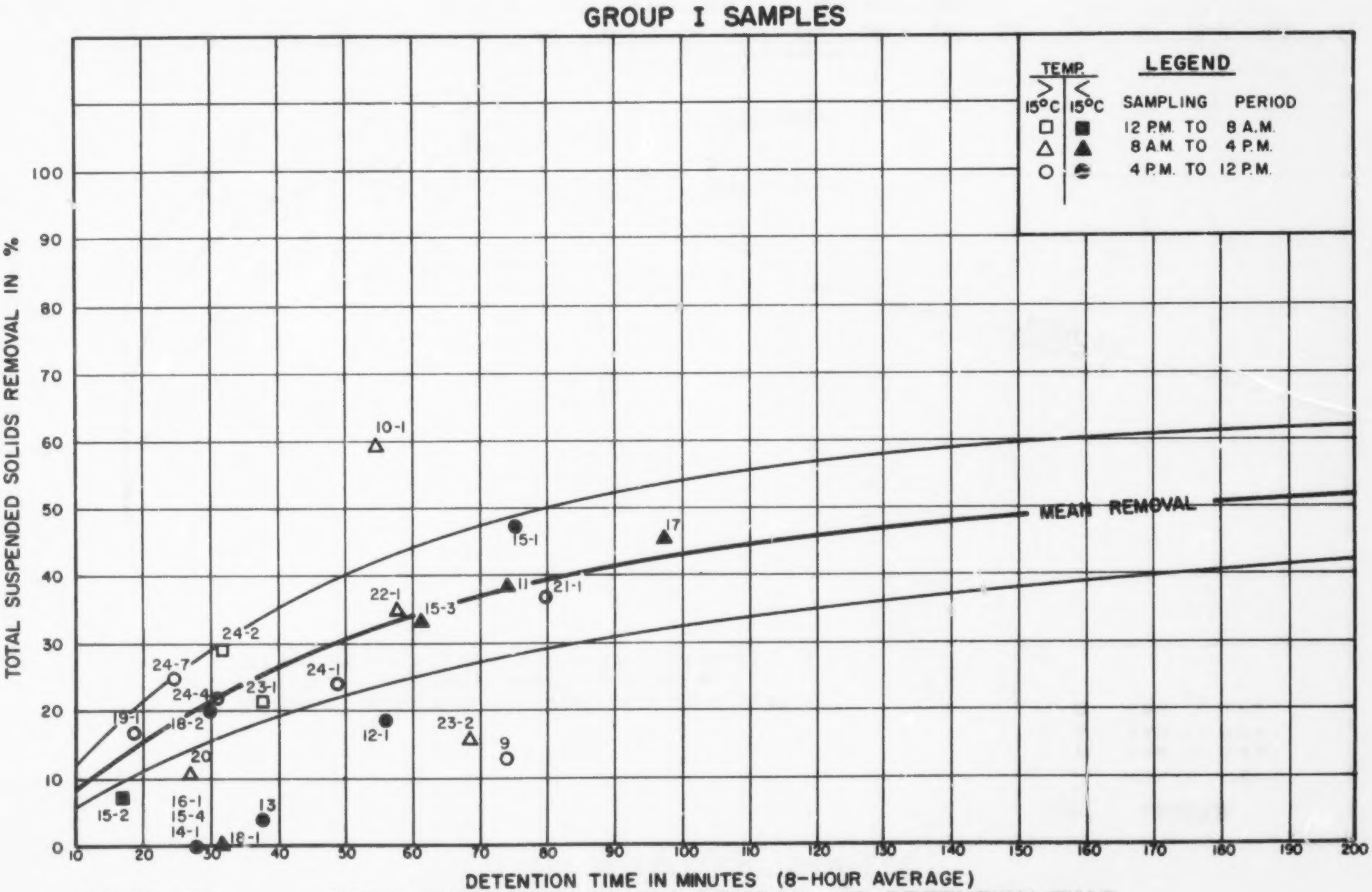


FIGURE 25 TOTAL SUSPENDED SOLIDS REMOVAL VS. DETENTION TIME

GROUP II SAMPLES

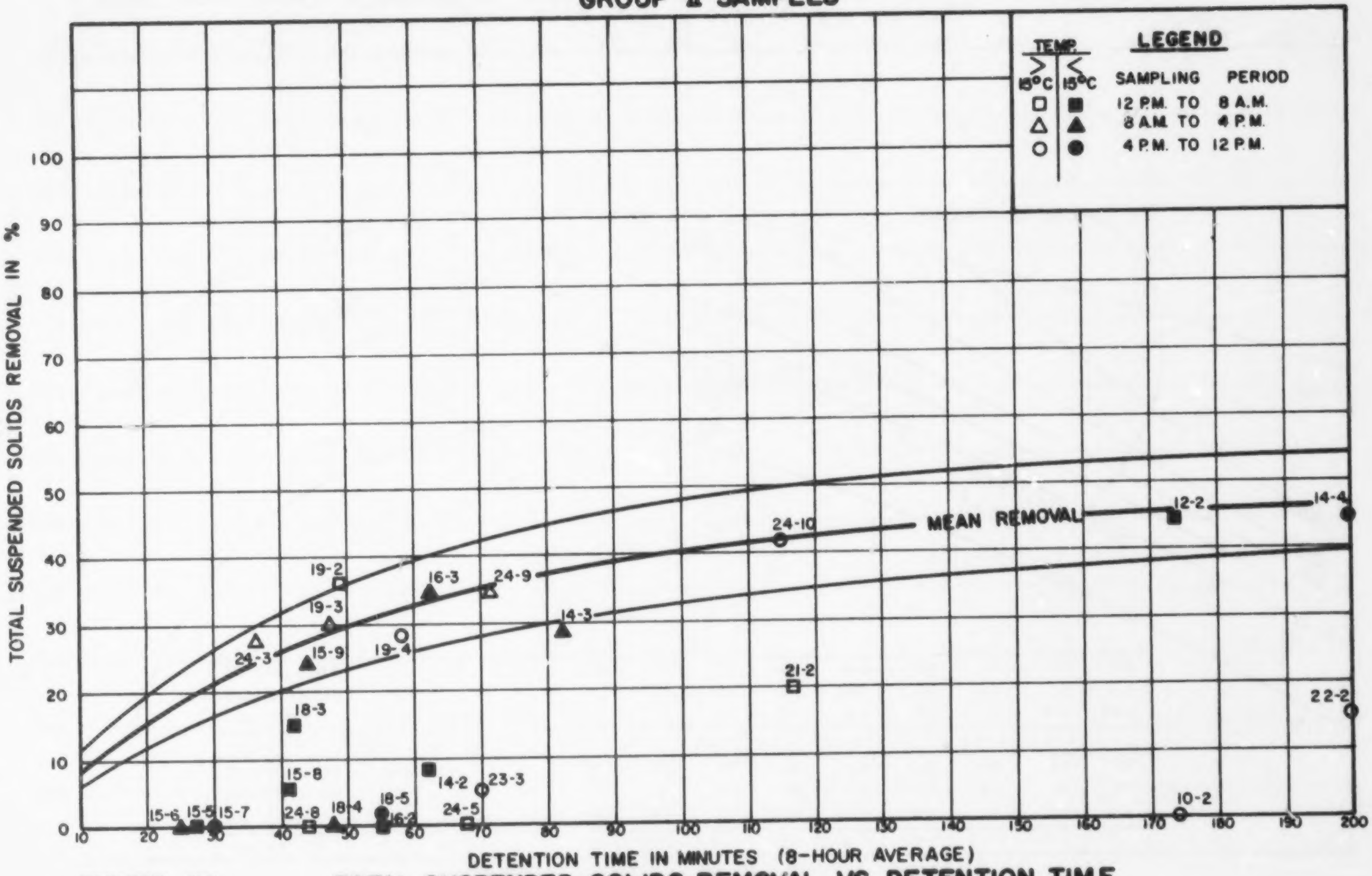
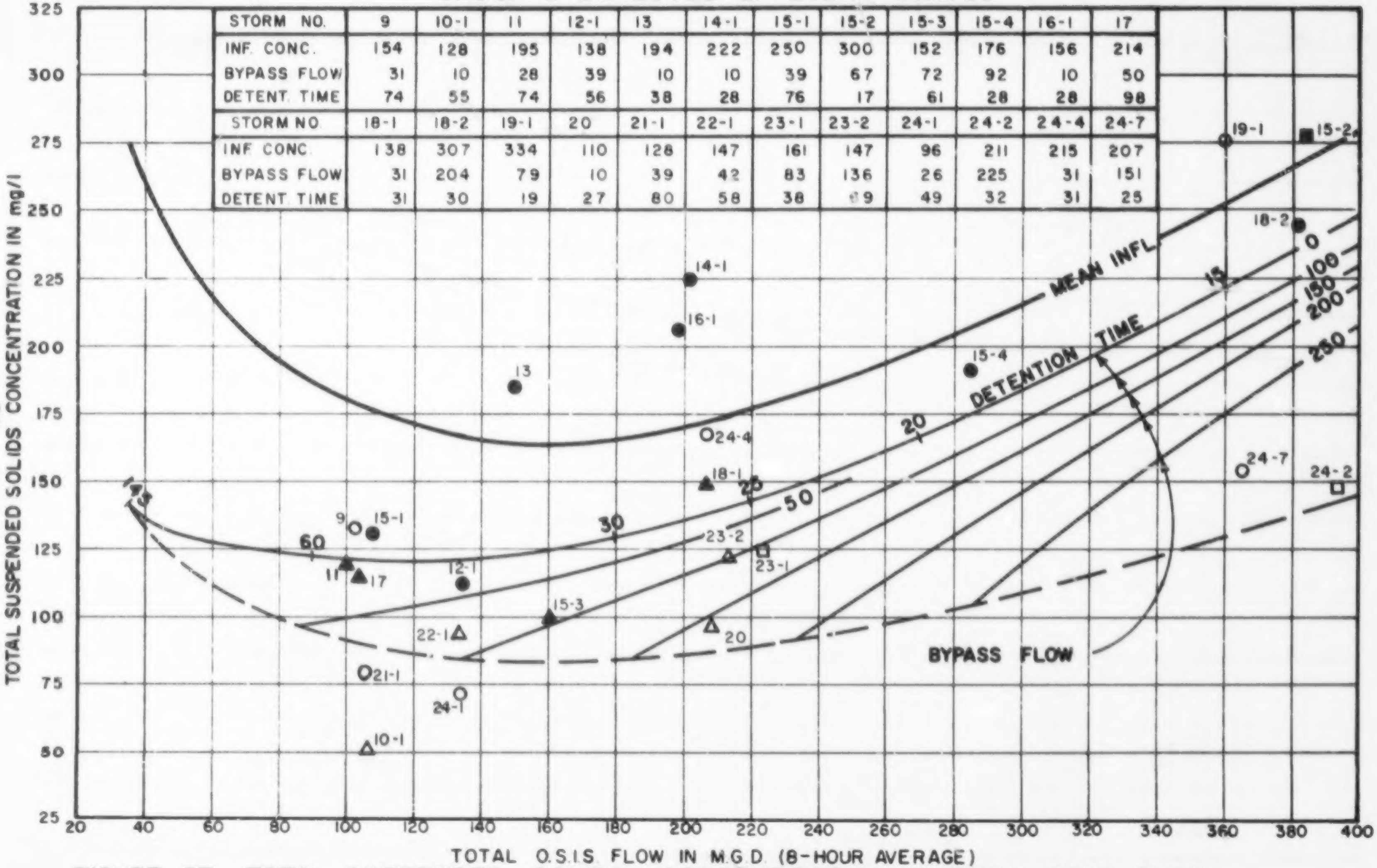


FIGURE 26 TOTAL SUSPENDED SOLIDS REMOVAL VS. DETENTION TIME

GROUP I EXPECTED EFFLUENT CURVES



STORM NO.	9	10-1	11	12-1	13	14-1	15-1	15-2	15-3	15-4	16-1	17
INF. CONC.	154	128	195	138	194	222	250	300	152	176	156	214
BYPASS FLOW	31	10	28	39	10	10	39	67	72	92	10	50
DETENT. TIME	74	55	74	56	38	28	76	17	61	28	28	98

STORM NO.	18-1	18-2	19-1	20	21-1	22-1	23-1	23-2	24-1	24-2	24-4	24-7
INF. CONC.	138	307	334	110	128	147	161	147	96	211	215	207
BYPASS FLOW	31	204	79	10	39	42	83	136	26	225	31	151
DETENT. TIME	31	30	19	27	80	58	38	[illegible]9	49	32	31	25

FIGURE 27 TOTAL SUSPENDED SOLIDS CONCENTRATION VS. TOTAL O.S.I.S. FLOW

GROUP II EXPECTED EFFLUENT CURVES

STORM NO.	10-2	12-2	14-2	14-3	14-4	15-5	15-6	15-7	15-8	15-9	16-2	16-3	18-3
INF. CONC.	90	72	94	114	108	90	82	96	76	100	52	68	68
BYPASS FLOW	50	39	28	13	34	10	10	10	10	10	10	10	10
DETENT. TIME	174	174	62	82	216	27	25	30	41	44	55	62	42
STORM NO.	18-4	18-5	19-2	19-3	19-4	21-2	22-2	23-3	24-3	24-5	24-8	24-9	24-10
INF. CONC.	76	89	116	144	134	122	87	83	109	48	45	103	140
BYPASS FLOW	22	16	20	10	20	39	40	10	10	20	14	34	43
DETENT. TIME	48	55	49	47	53	117	225	70	36	68	44	71	115

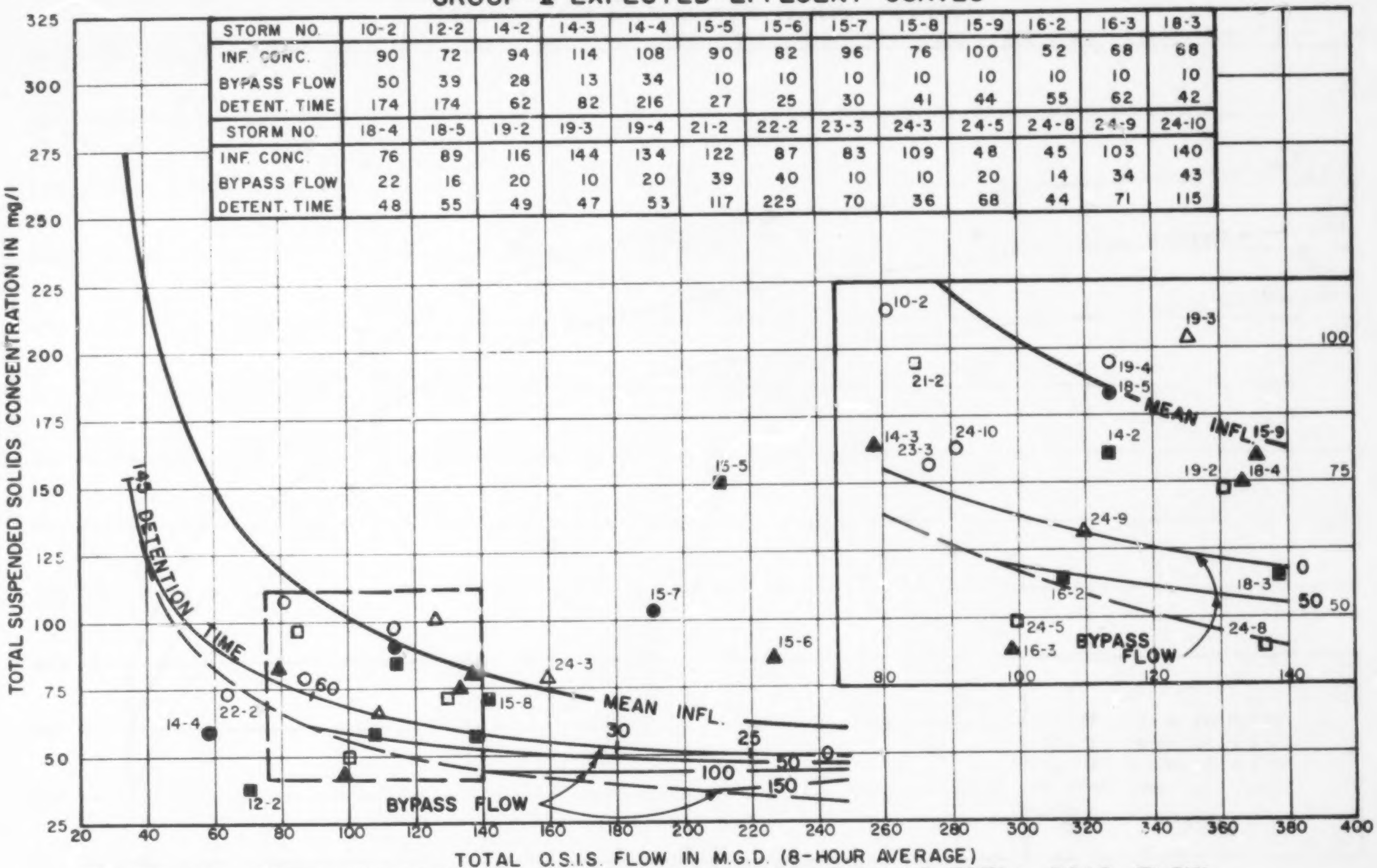


FIGURE 28 TOTAL SUSPENDED SOLIDS CONCENTRATION VS. TOTAL O.S.I.S. FLOW

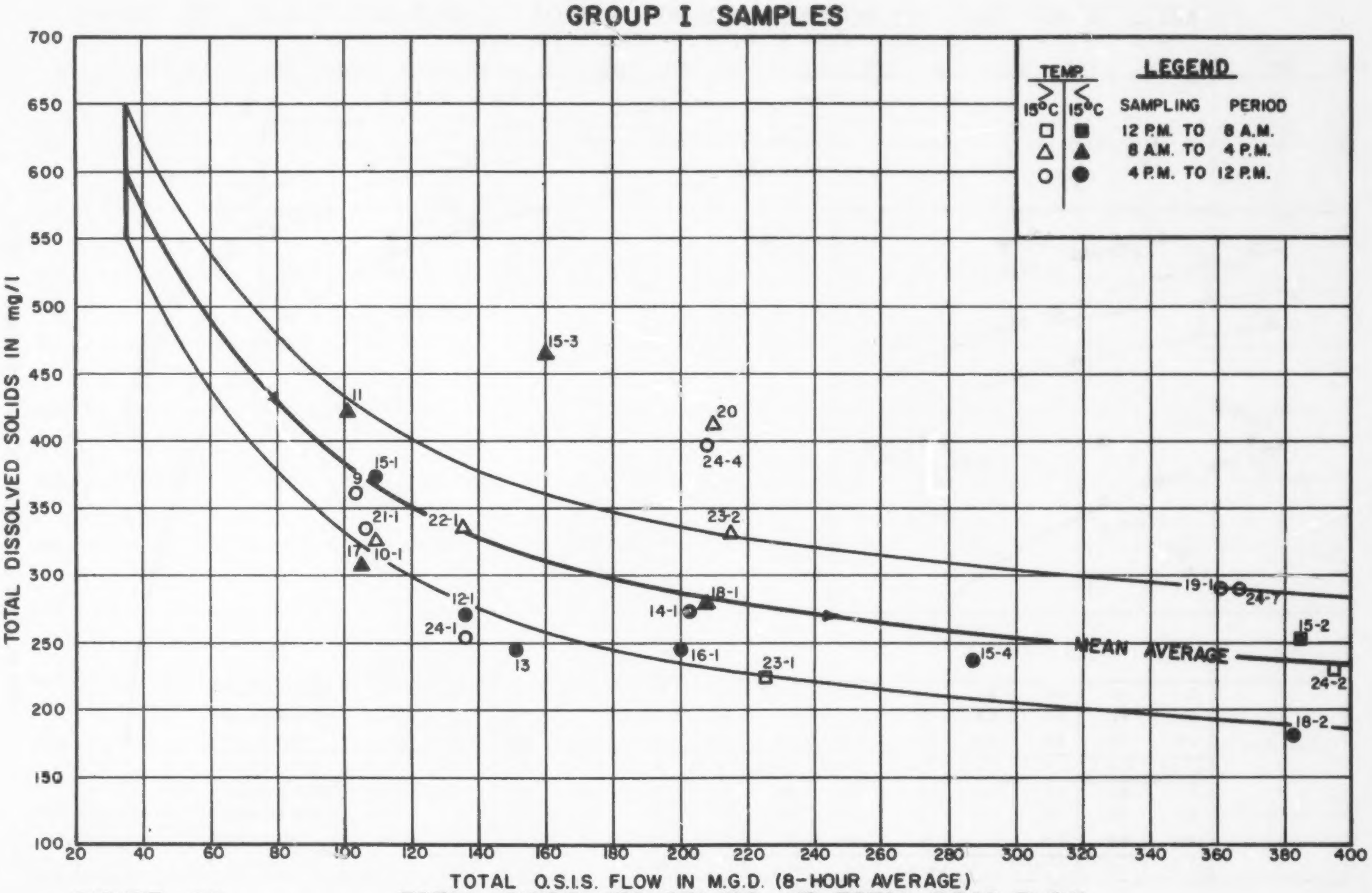


FIGURE 29

TOTAL DISSOLVED SOLIDS VS. TOTAL O.S.I.S. FLOW

GROUP II SAMPLES

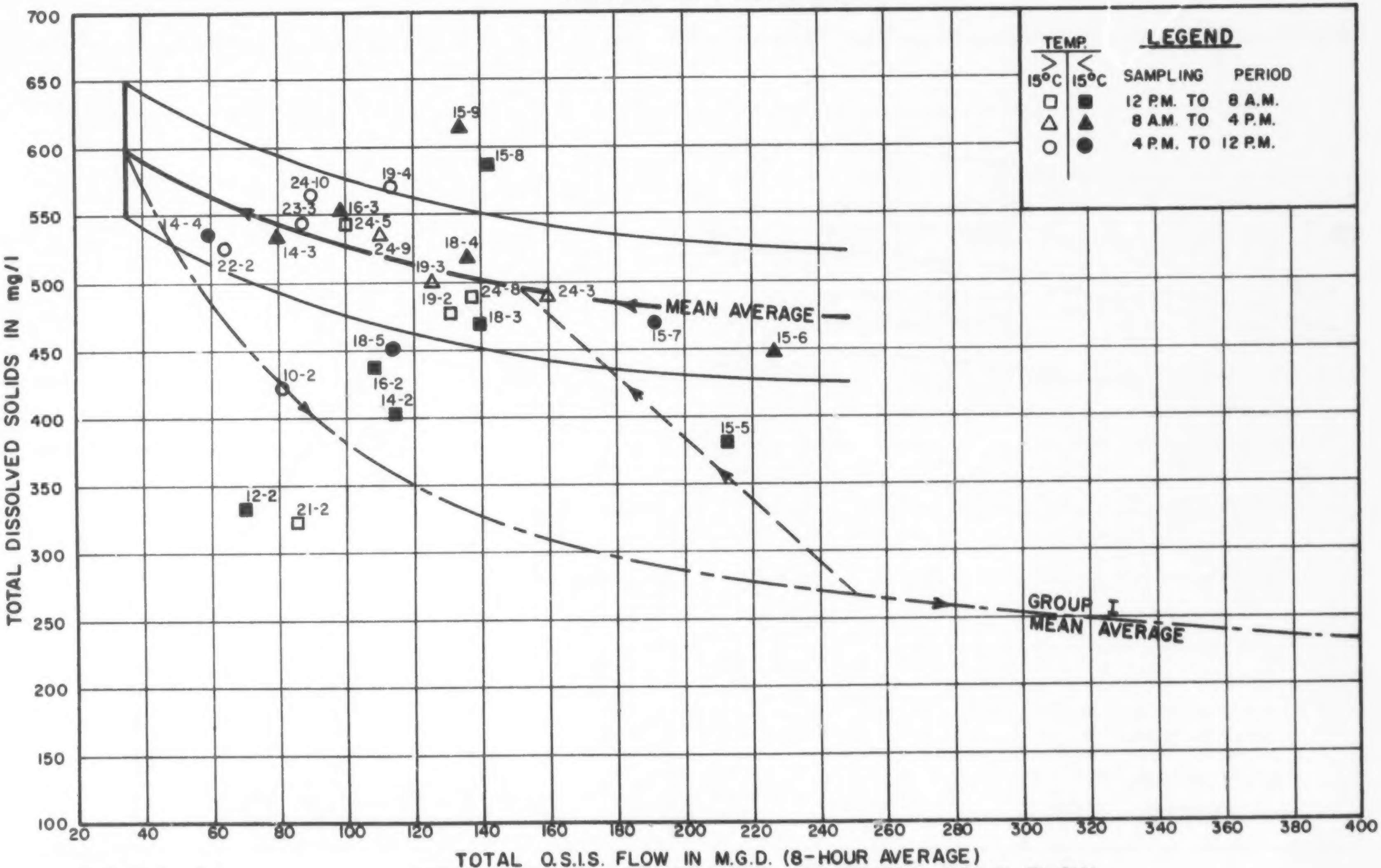
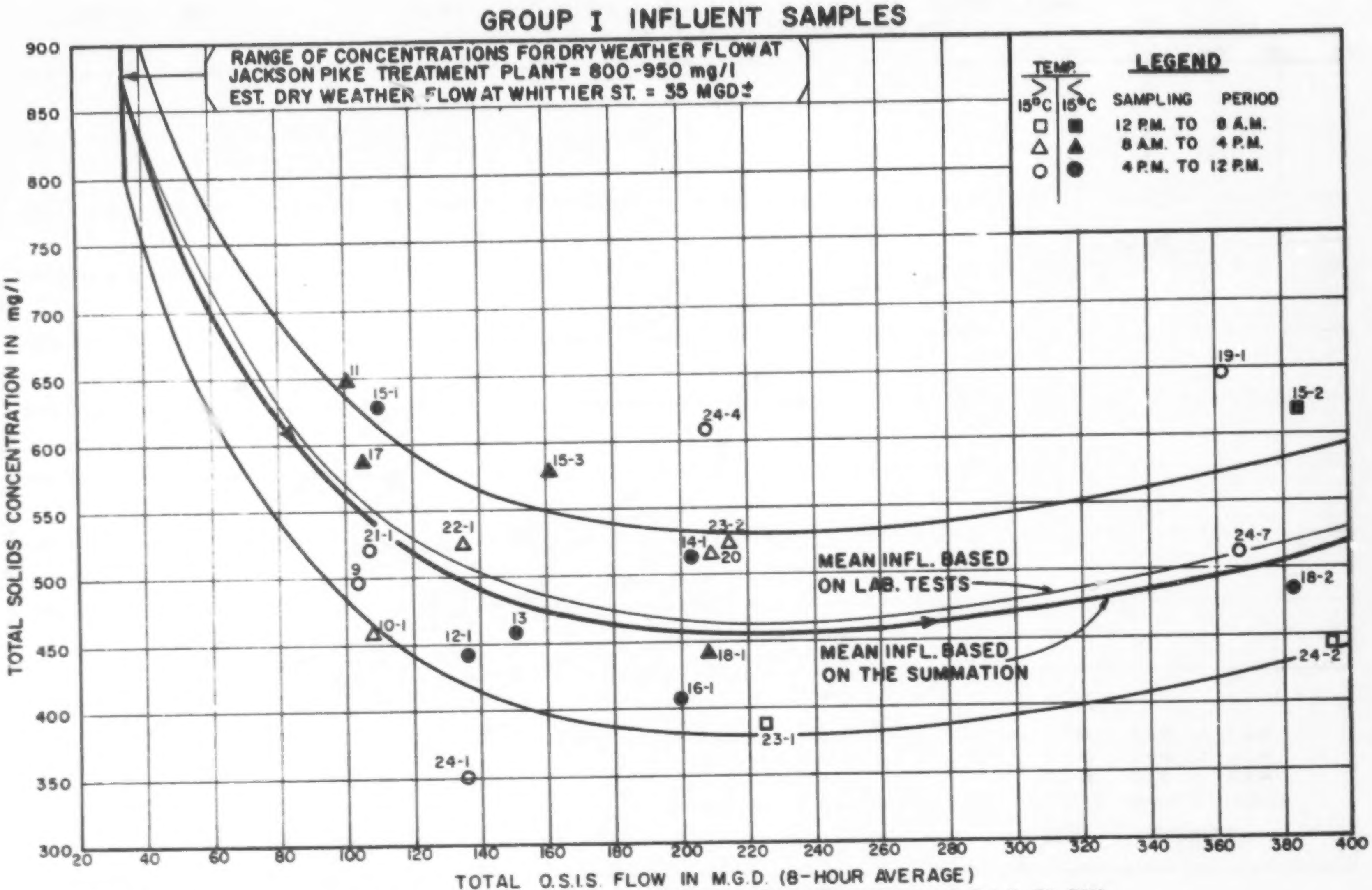


FIGURE 30 TOTAL DISSOLVED SOLIDS VS. TOTAL O.S.I.S. FLOW



GROUP I INFLUENT SAMPLES

FIGURE 31 TOTAL SOLIDS CONCENTRATION VS. TOTAL O.S.I.S. FLOW

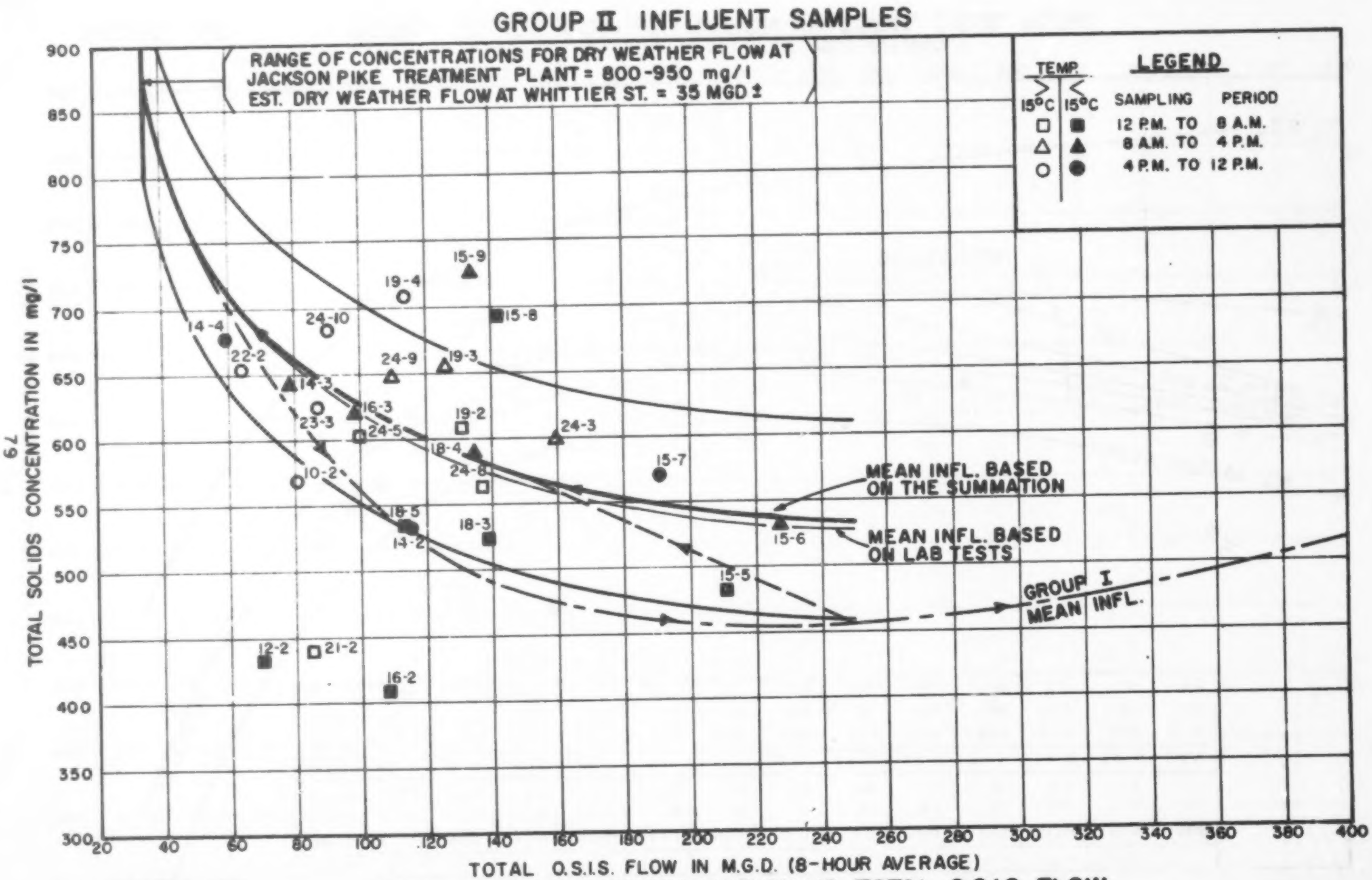
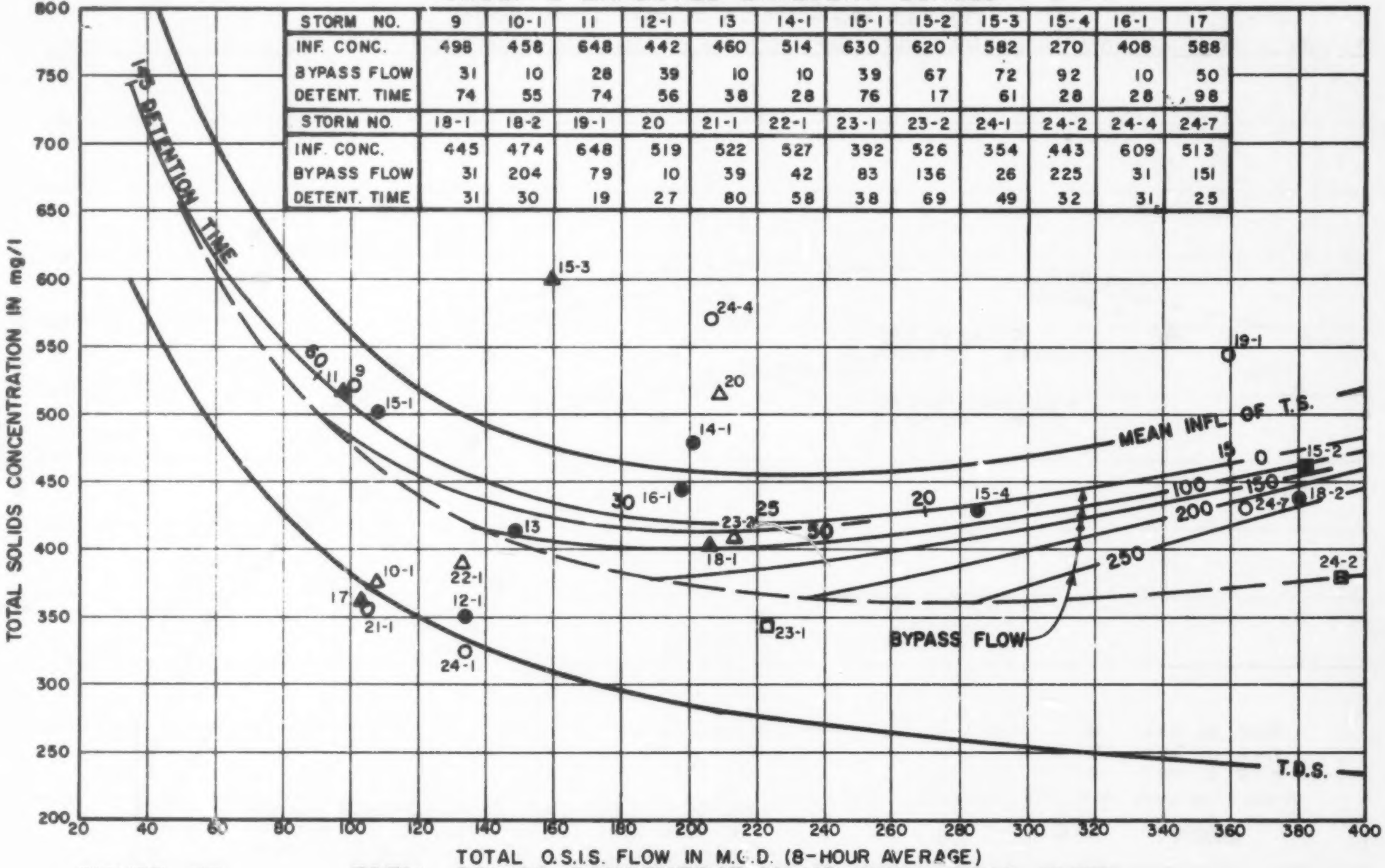


FIGURE 32 TOTAL SOLIDS CONCENTRATION VS. TOTAL O.S.I.S. FLOW

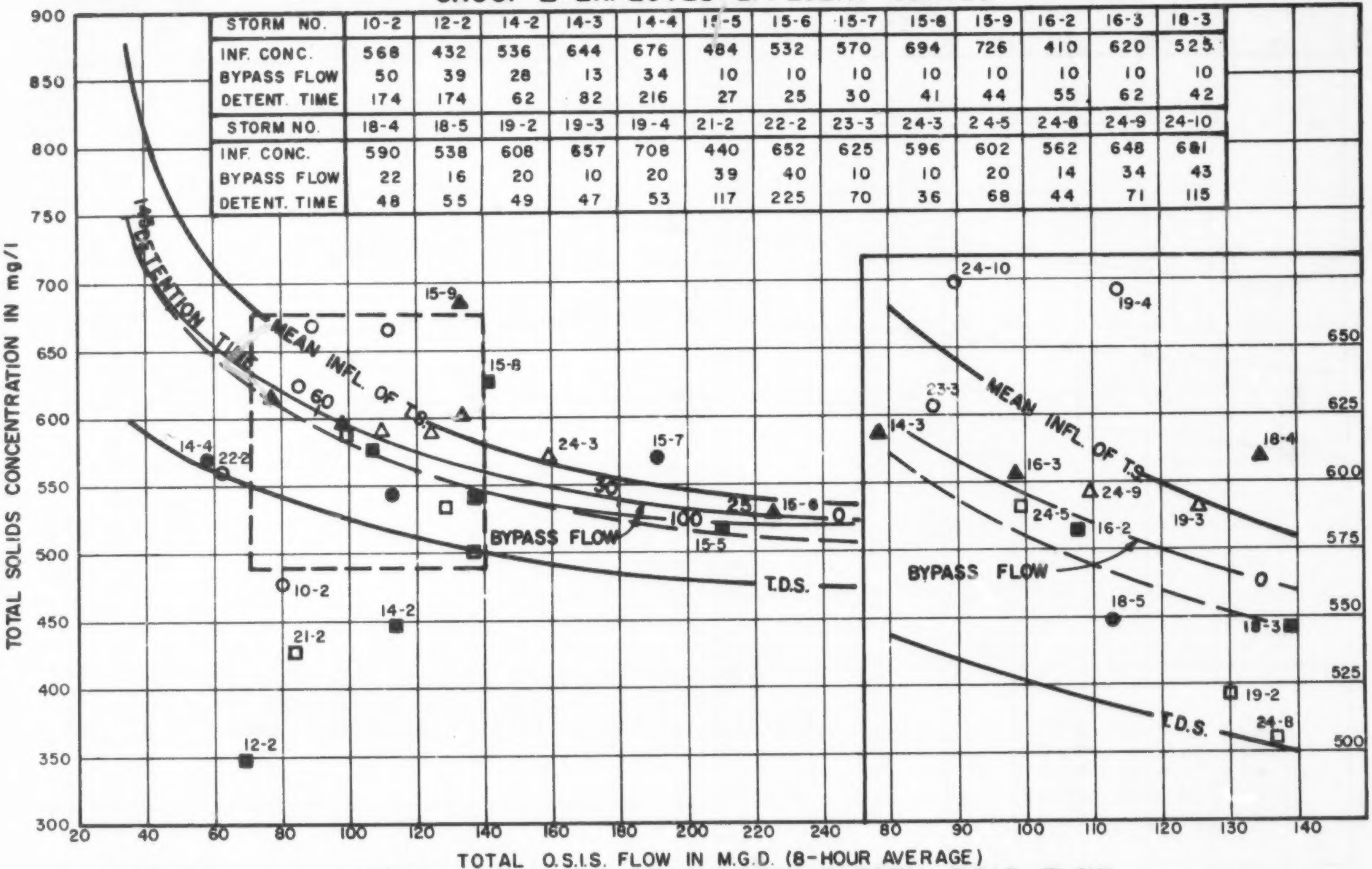
GROUP I EXPECTED EFFLUENT CURVES



STORM NO.	9	10-1	11	12-1	13	14-1	15-1	15-2	15-3	15-4	16-1	17
INF. CONC.	498	458	648	442	460	514	630	620	582	270	408	588
BYPASS FLOW	31	10	28	39	10	10	39	67	72	92	10	50
DETENT. TIME	74	55	74	56	38	28	76	17	61	28	28	98
STORM NO.	18-1	18-2	19-1	20	21-1	22-1	23-1	23-2	24-1	24-2	24-4	24-7
INF. CONC.	445	474	648	519	522	527	392	526	354	443	609	513
BYPASS FLOW	31	204	79	10	39	42	83	136	26	225	31	151
DETENT. TIME	31	30	19	27	80	58	38	69	49	32	31	25

FIGURE 33 TOTAL SOLIDS CONCENTRATION VS. TOTAL O.S.I.S. FLOW

GROUP II EXPECTED EFFLUENT CURVES



STORM NO.	10-2	12-2	14-2	14-3	14-4	15-5	15-6	15-7	15-8	15-9	16-2	16-3	18-3
INF. CONC.	568	432	536	644	676	484	532	570	694	726	410	620	525
BYPASS FLOW	50	39	28	13	34	10	10	10	10	10	10	10	10
DETENT. TIME	174	174	62	82	216	27	25	30	41	44	55	62	42
STORM NO.	18-4	18-5	19-2	19-3	19-4	21-2	22-2	23-3	24-3	24-5	24-8	24-9	24-10
INF. CONC.	590	538	608	657	708	440	652	625	596	602	562	648	681
BYPASS FLOW	22	16	20	10	20	39	40	10	10	20	14	34	43
DETENT. TIME	48	55	49	47	53	117	225	70	36	68	44	71	115

FIGURE 34 TOTAL SOLIDS CONCENTRATION VS. TOTAL O.S.I.S. FLOW

GROUP I INFLUENT SAMPLES

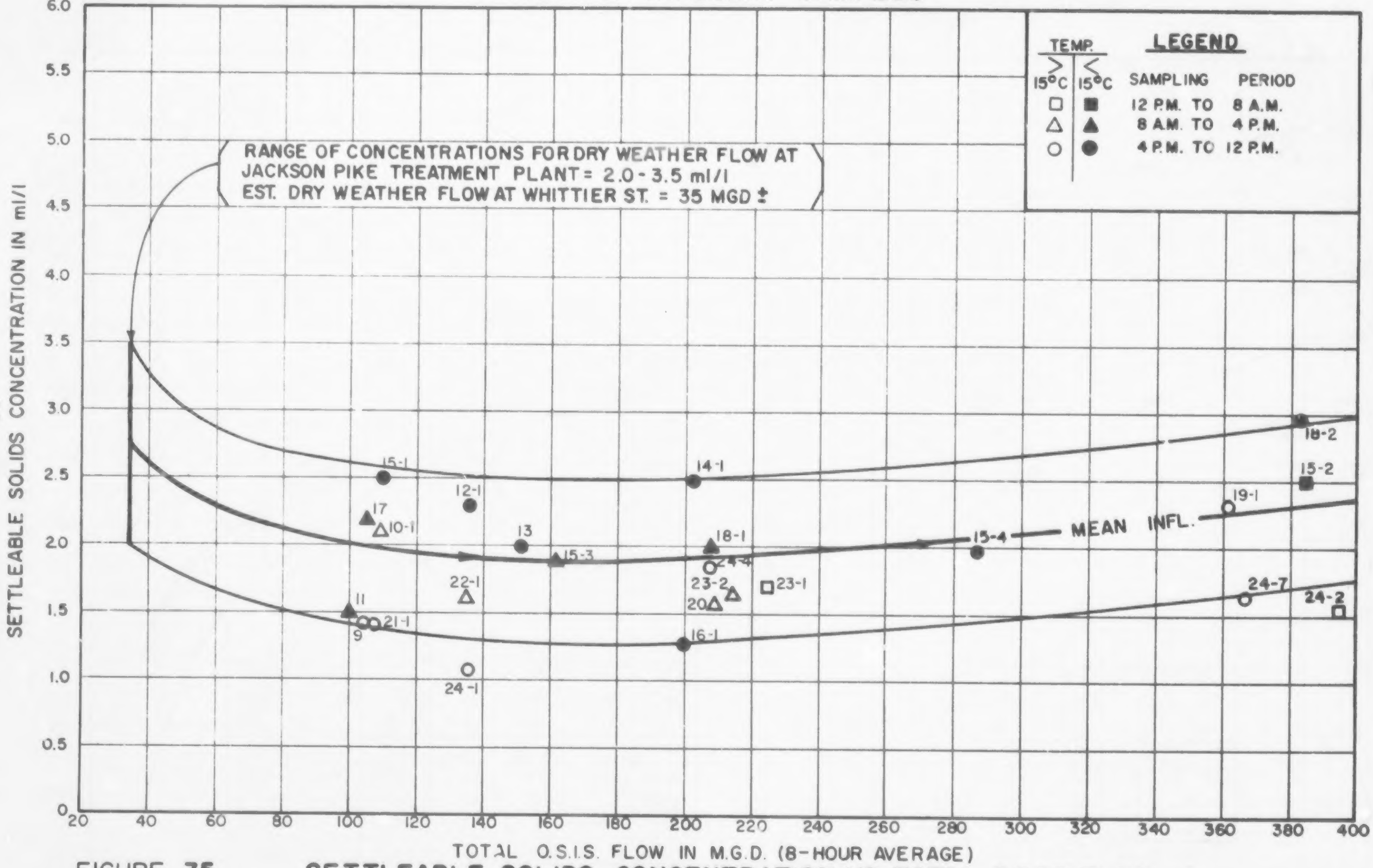


FIGURE 35 SETTLEABLE SOLIDS CONCENTRATION VS. TOTAL O.S.I.S. FLOW

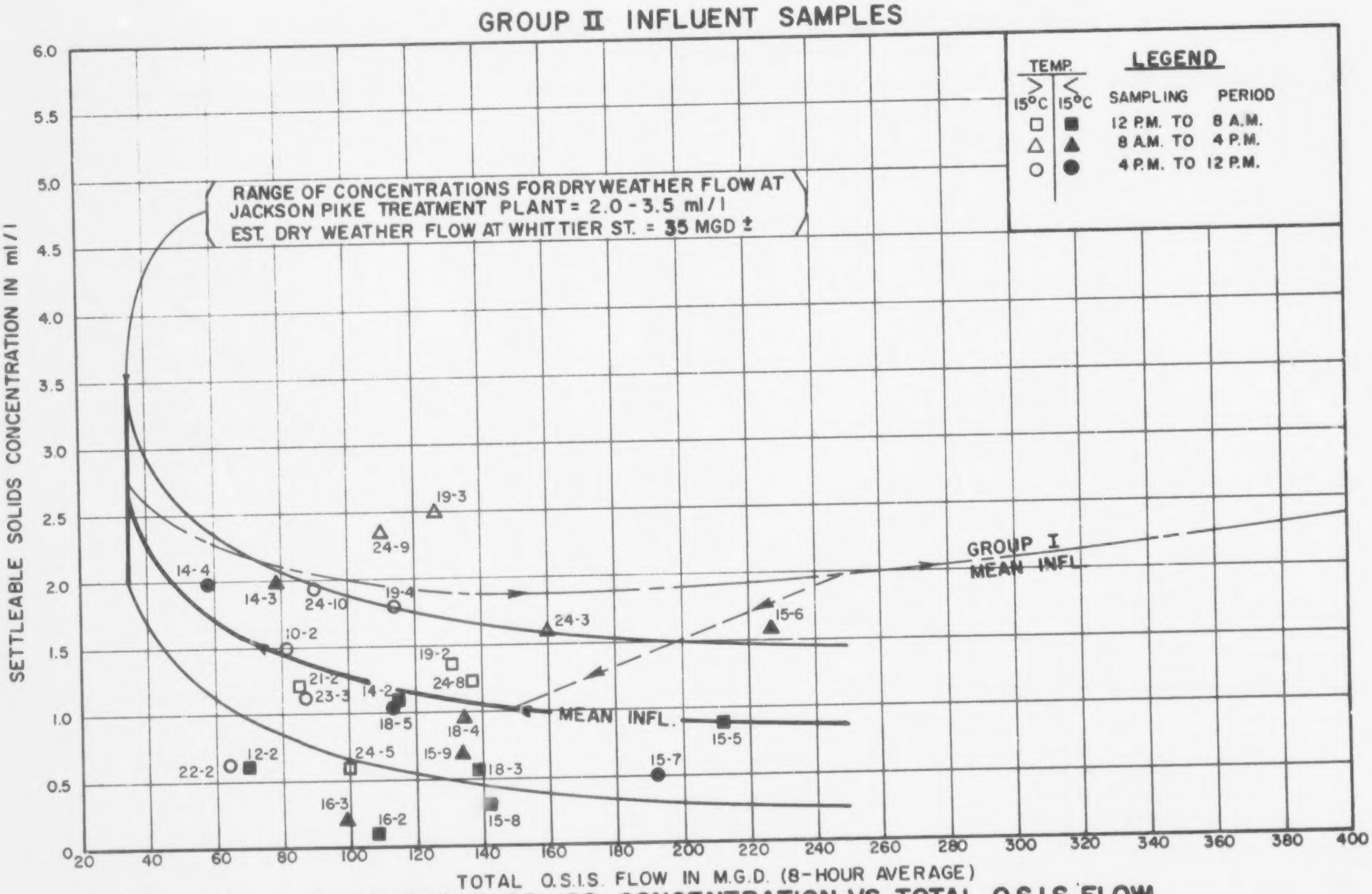


FIGURE 36 SETTLEABLE SOLIDS CONCENTRATION VS. TOTAL O.S.I.S. FLOW

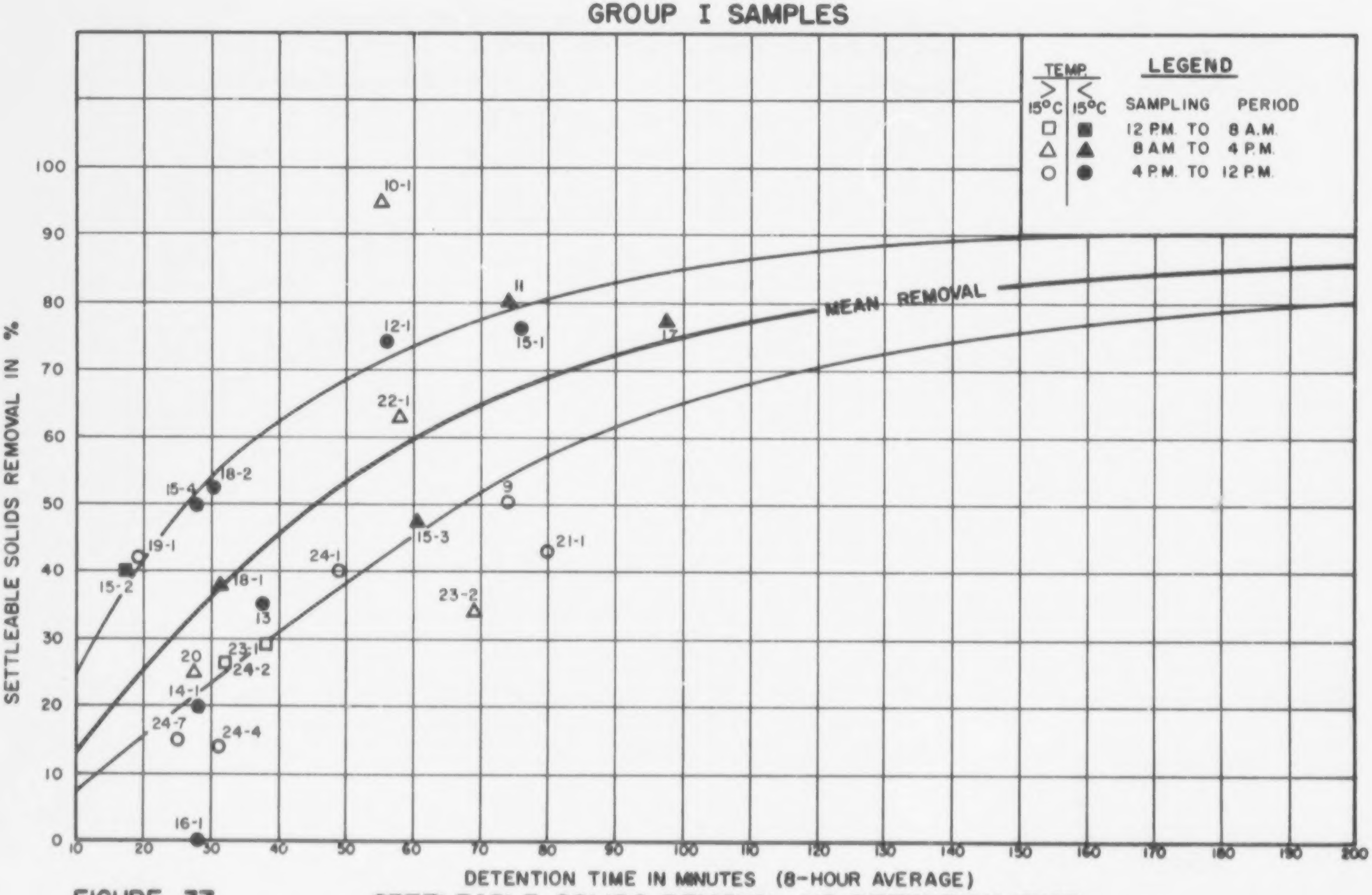


FIGURE 37

SETTLEABLE SOLIDS REMOVAL VS. DETENTION TIME

GROUP II SAMPLES

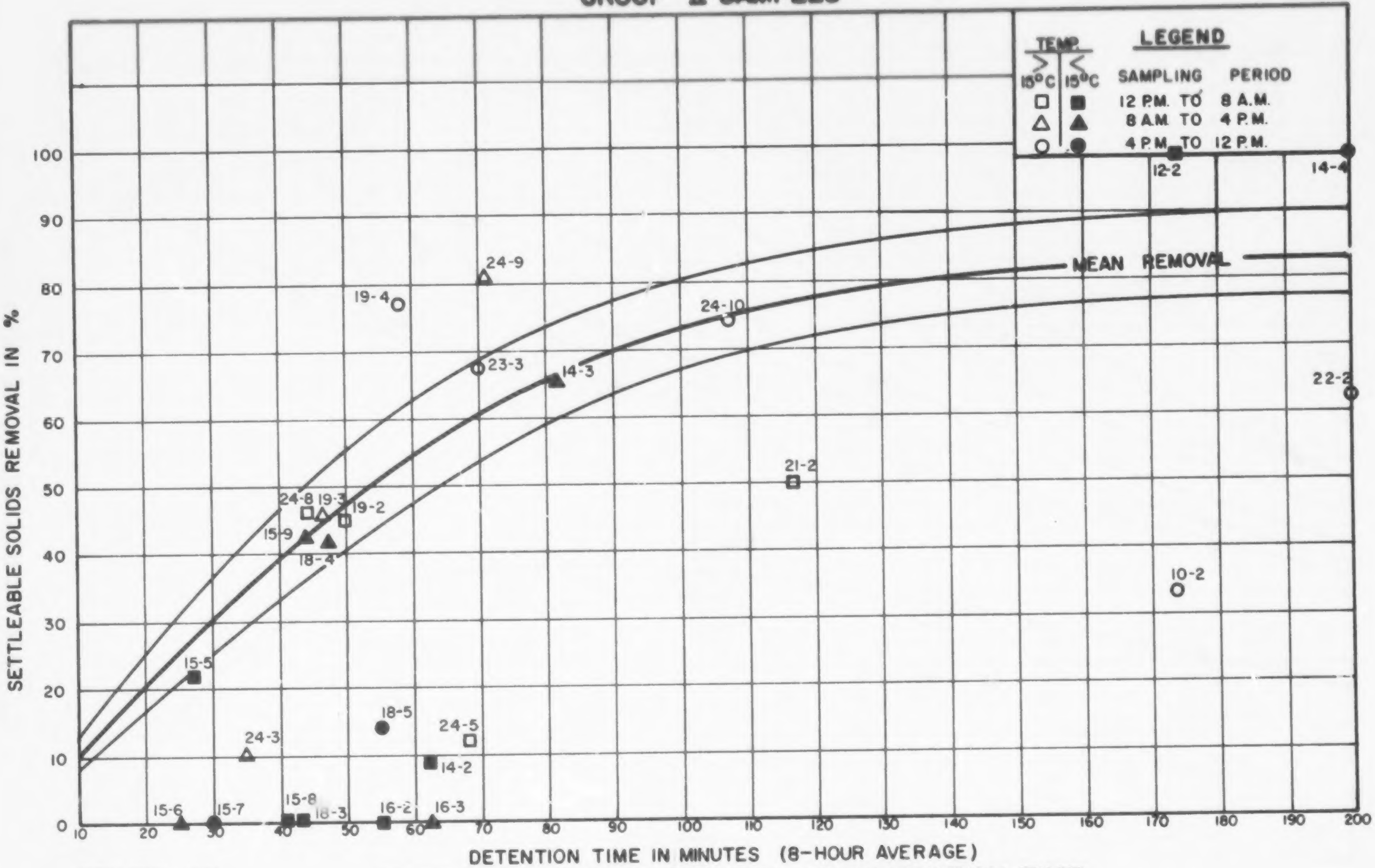
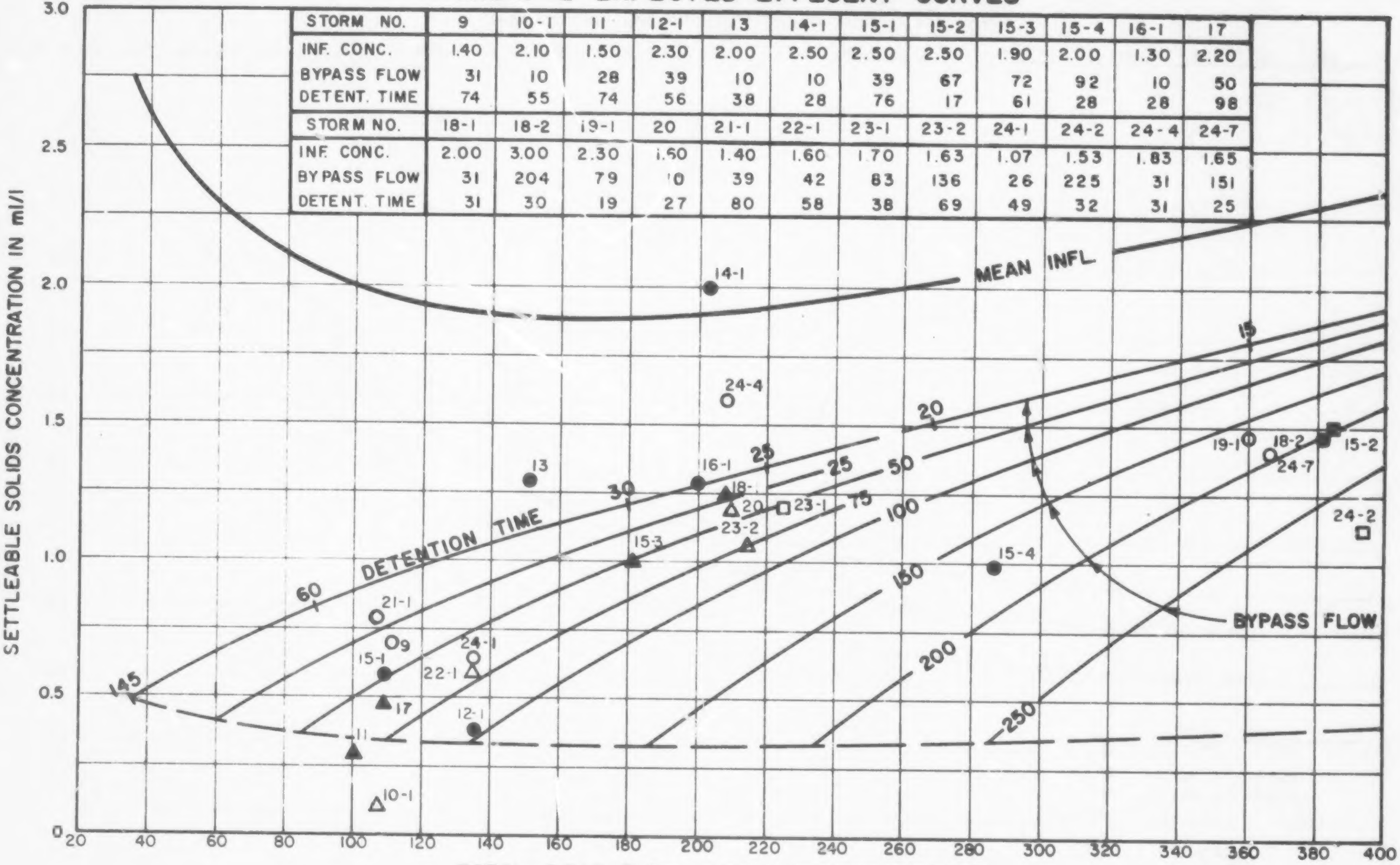


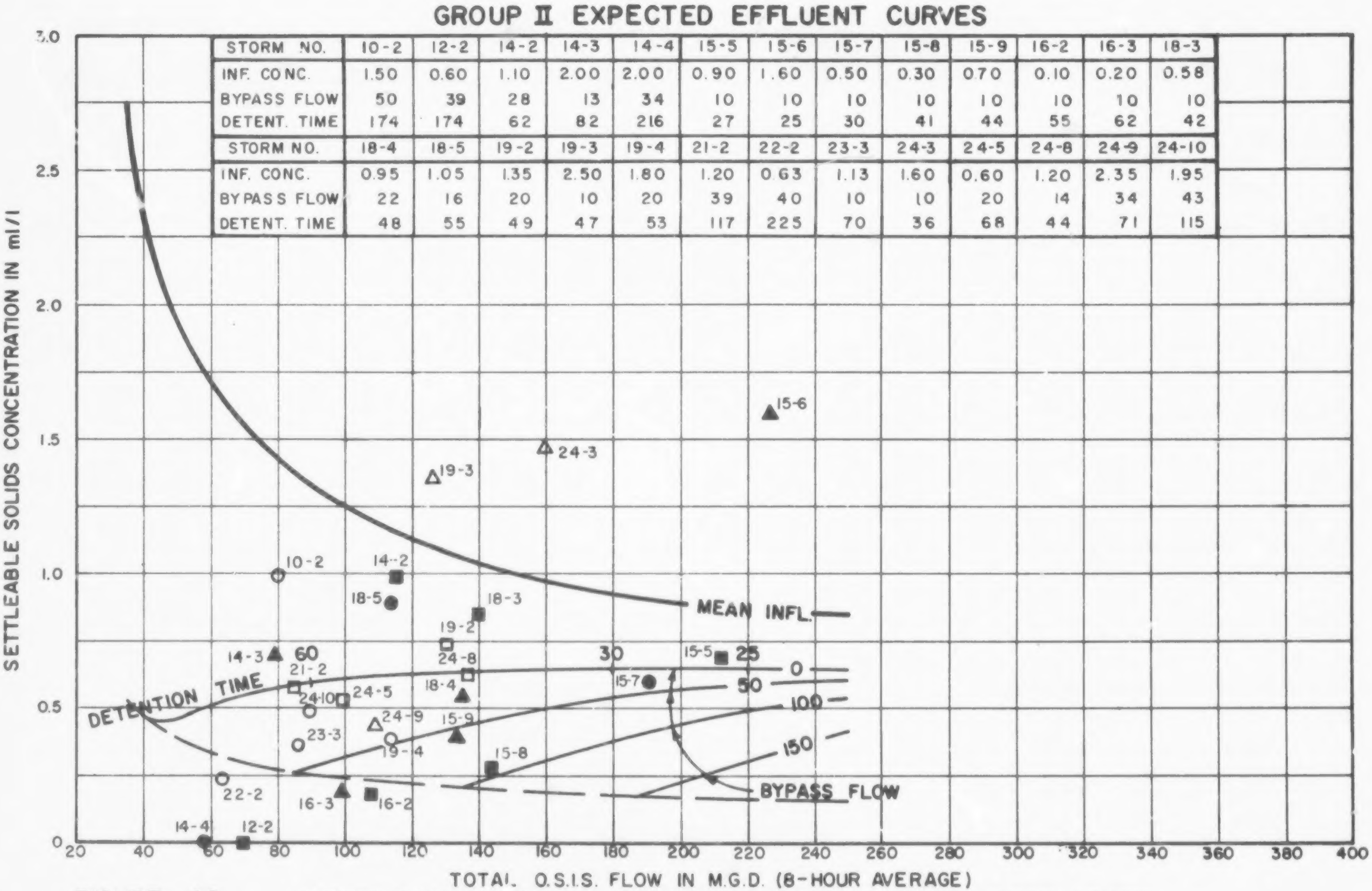
FIGURE 38 SETTLEABLE SOLIDS REMOVAL VS. DETENTION TIME

GROUP I EXPECTED EFFLUENT CURVES



STORM NO.	9	10-1	11	12-1	13	14-1	15-1	15-2	15-3	15-4	16-1	17
INF. CONC.	1.40	2.10	1.50	2.30	2.00	2.50	2.50	2.50	1.90	2.00	1.30	2.20
BYPASS FLOW	31	10	28	39	10	10	39	67	72	92	10	50
DETENT. TIME	74	55	74	56	38	28	76	17	61	28	28	98
STORM NO.	18-1	18-2	19-1	20	21-1	22-1	23-1	23-2	24-1	24-2	24-4	24-7
INF. CONC.	2.00	3.00	2.30	1.60	1.40	1.60	1.70	1.63	1.07	1.53	1.83	1.65
BYPASS FLOW	31	204	79	10	39	42	83	136	26	225	31	151
DETENT. TIME	31	30	19	27	80	58	38	69	49	32	31	25

FIGURE 39 SETTLEABLE SOLIDS CONCENTRATION VS. TOTAL O.S.I.S. FLOW



STORM NO.	10-2	12-2	14-2	14-3	14-4	15-5	15-6	15-7	15-8	15-9	16-2	16-3	18-3
INF. CONC.	1.50	0.60	1.10	2.00	2.00	0.90	1.60	0.50	0.30	0.70	0.10	0.20	0.58
BYPASS FLOW	50	39	28	13	34	10	10	10	10	10	10	10	10
DETENT. TIME	174	174	62	82	216	27	25	30	41	44	55	62	42
STORM NO.	18-4	18-5	19-2	19-3	19-4	21-2	22-2	23-3	24-3	24-5	24-8	24-9	24-10
INF. CONC.	0.95	1.05	1.35	2.50	1.80	1.20	0.63	1.13	1.60	0.60	1.20	2.35	1.95
BYPASS FLOW	22	16	20	10	20	39	40	10	10	20	14	34	43
DETENT. TIME	48	55	49	47	53	117	225	70	36	68	44	71	115

FIGURE 40 SETTLEABLE SOLIDS CONCENTRATION VS. TOTAL O.S.I.S. FLOW

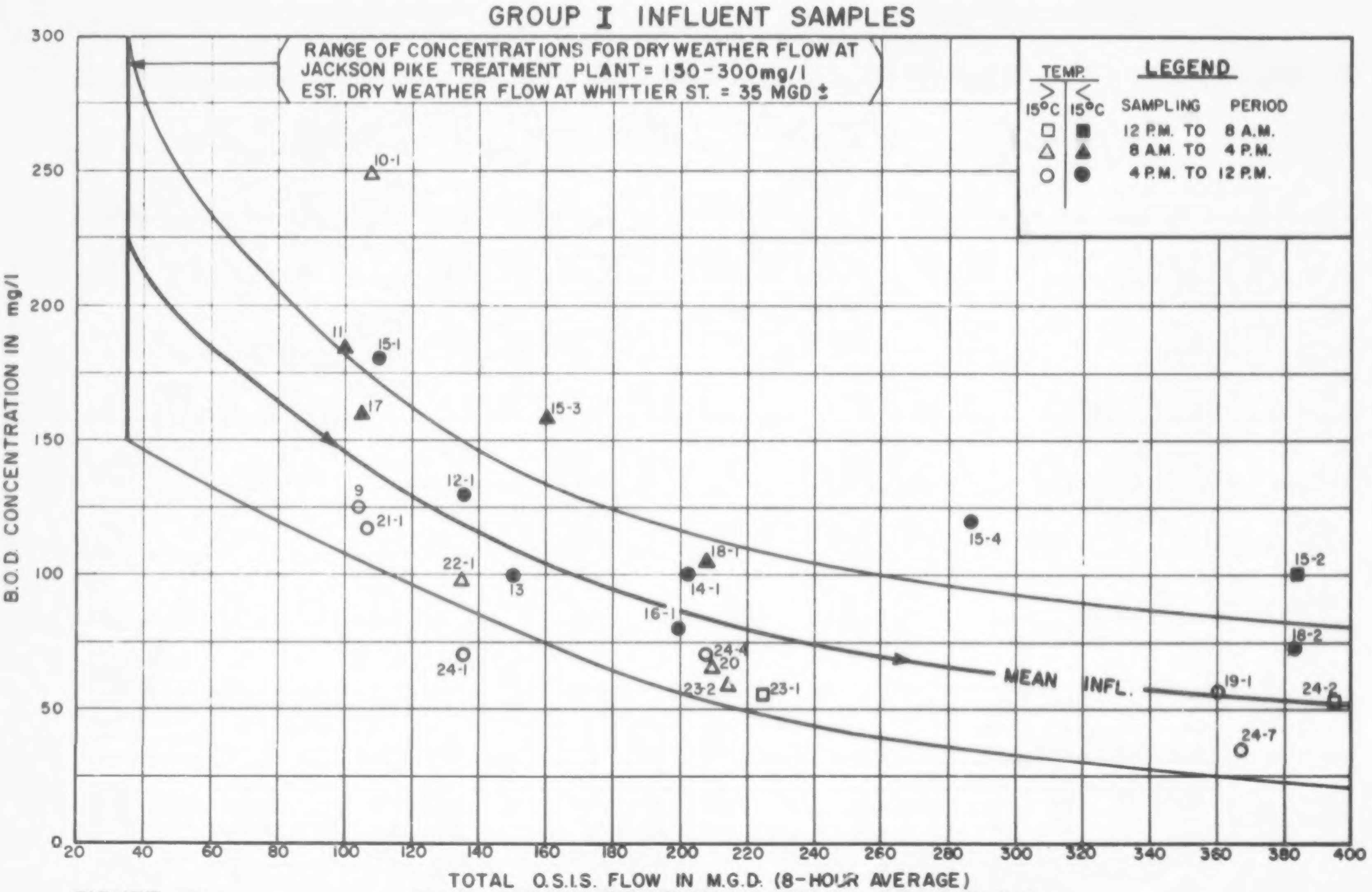


FIGURE 41

B.O.D. CONCENTRATION VS. TOTAL O.S.I.S. FLOW

GROUP II INFLUENT SAMPLES

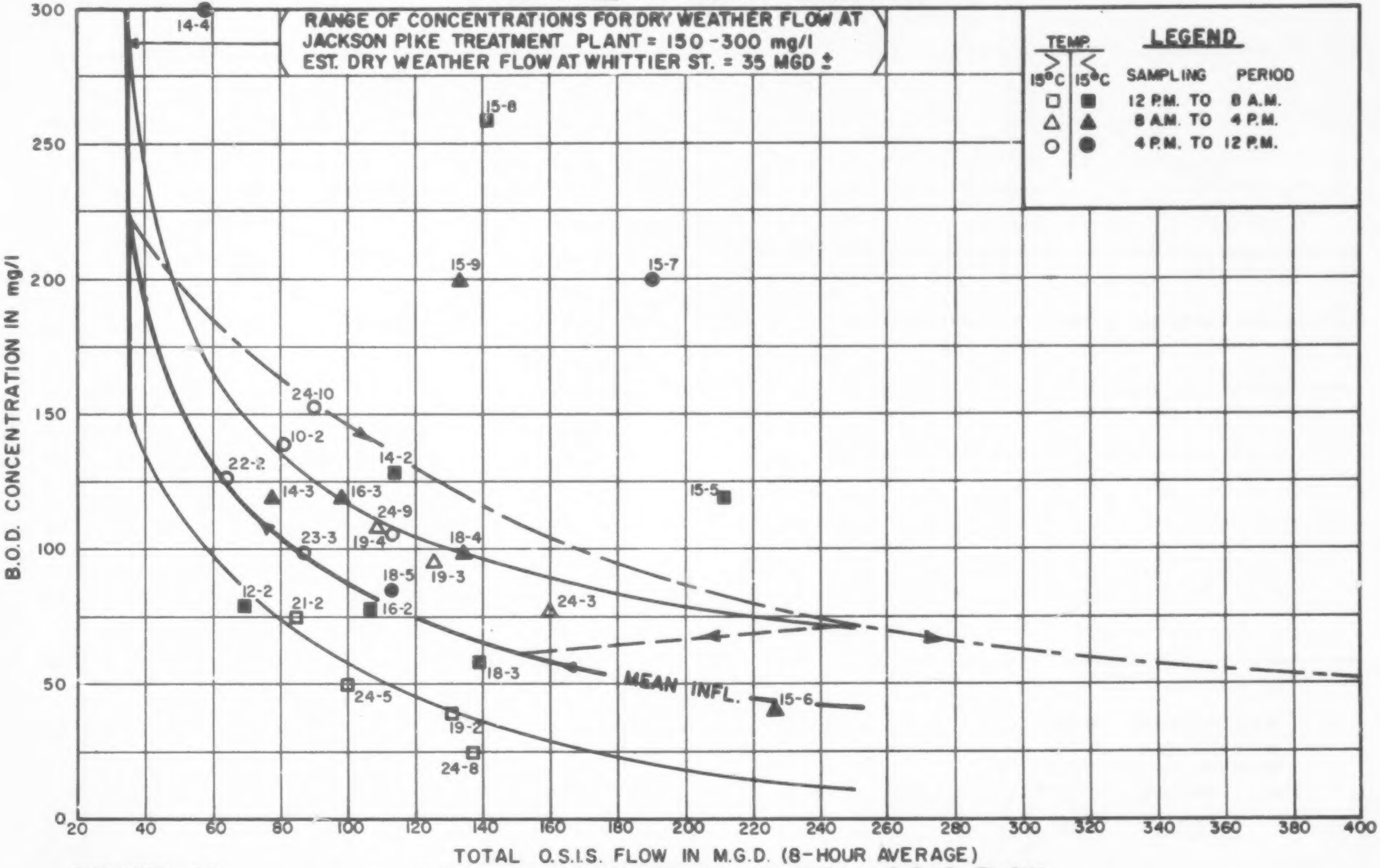


FIGURE 42

B.O.D. CONCENTRATION VS. TOTAL O.S.I.S. FLOW

GROUP I SAMPLES

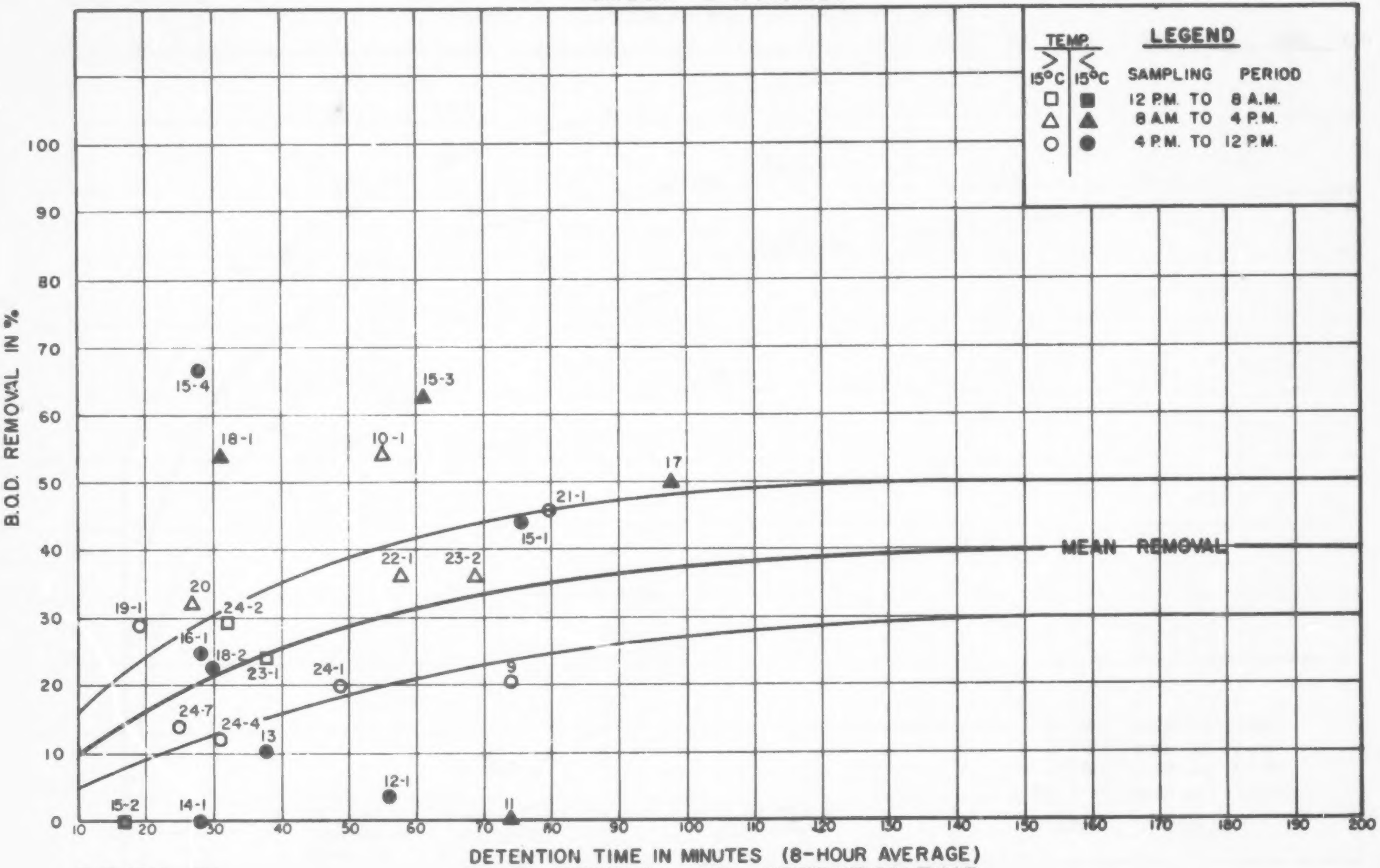


FIGURE 43

B.O.D. REMOVAL VS. DETENTION TIME

GROUP II SAMPLES

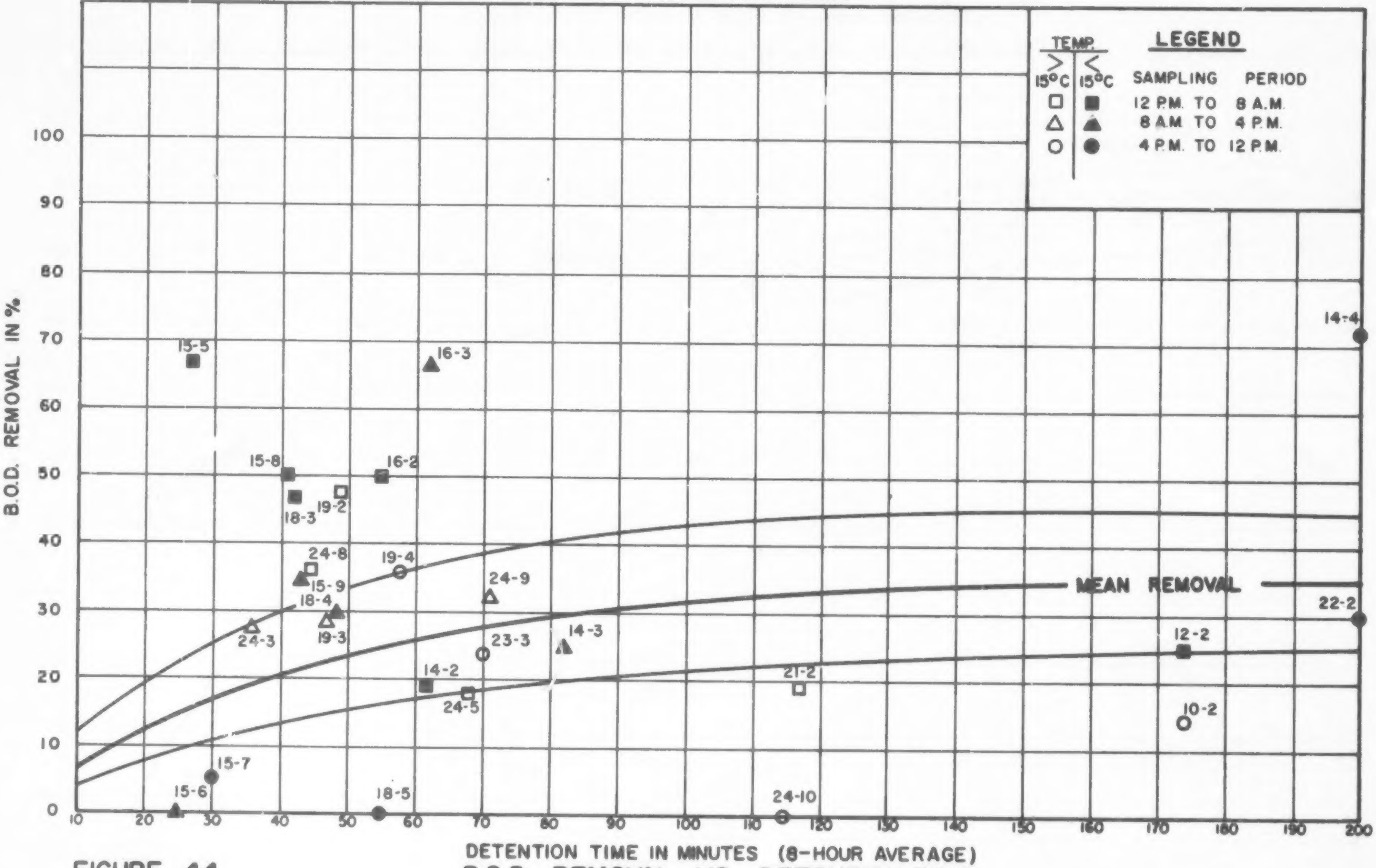
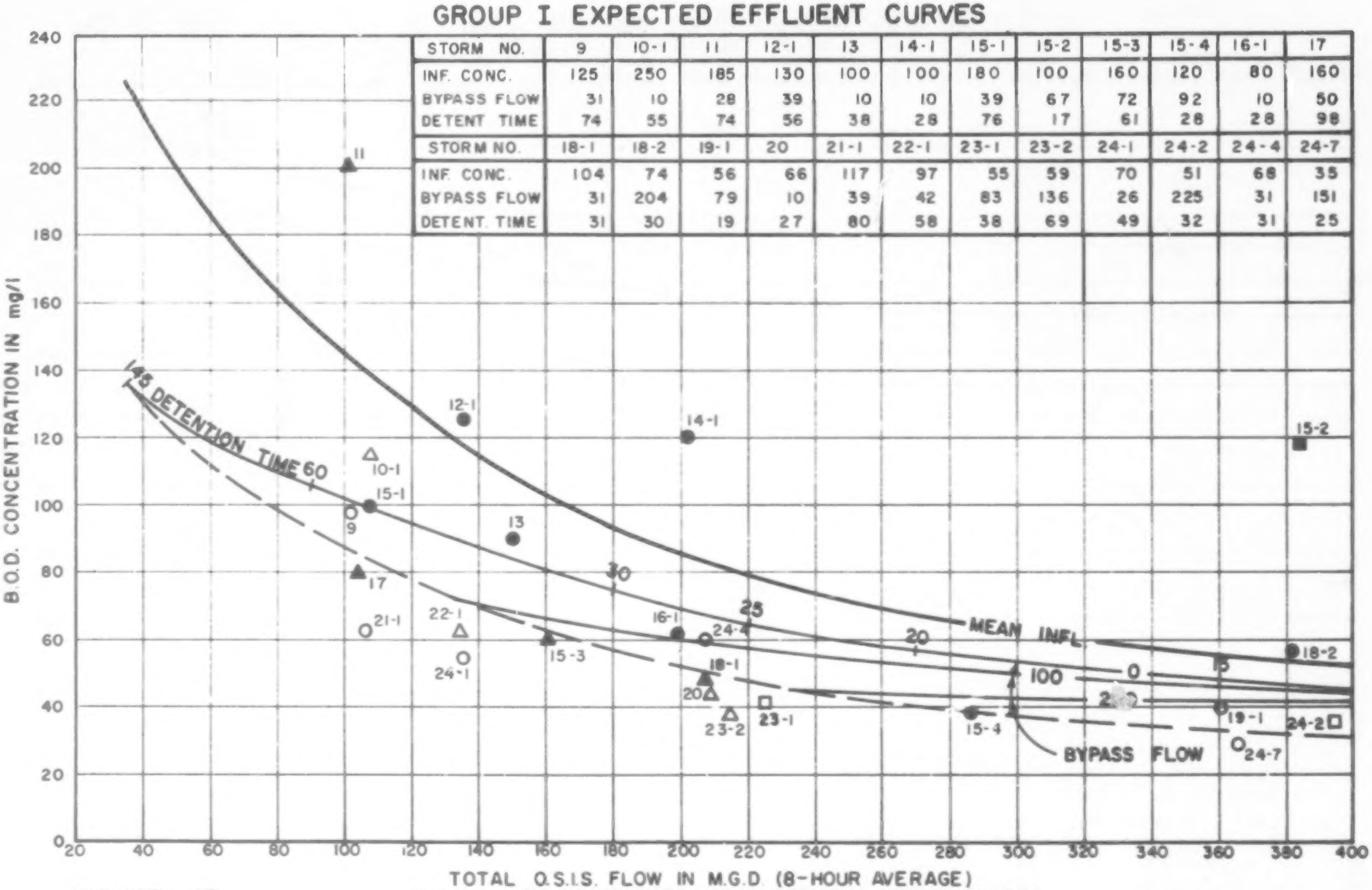


FIGURE 44

B.O.D. REMOVAL VS. DETENTION TIME

GROUP I EXPECTED EFFLUENT CURVES

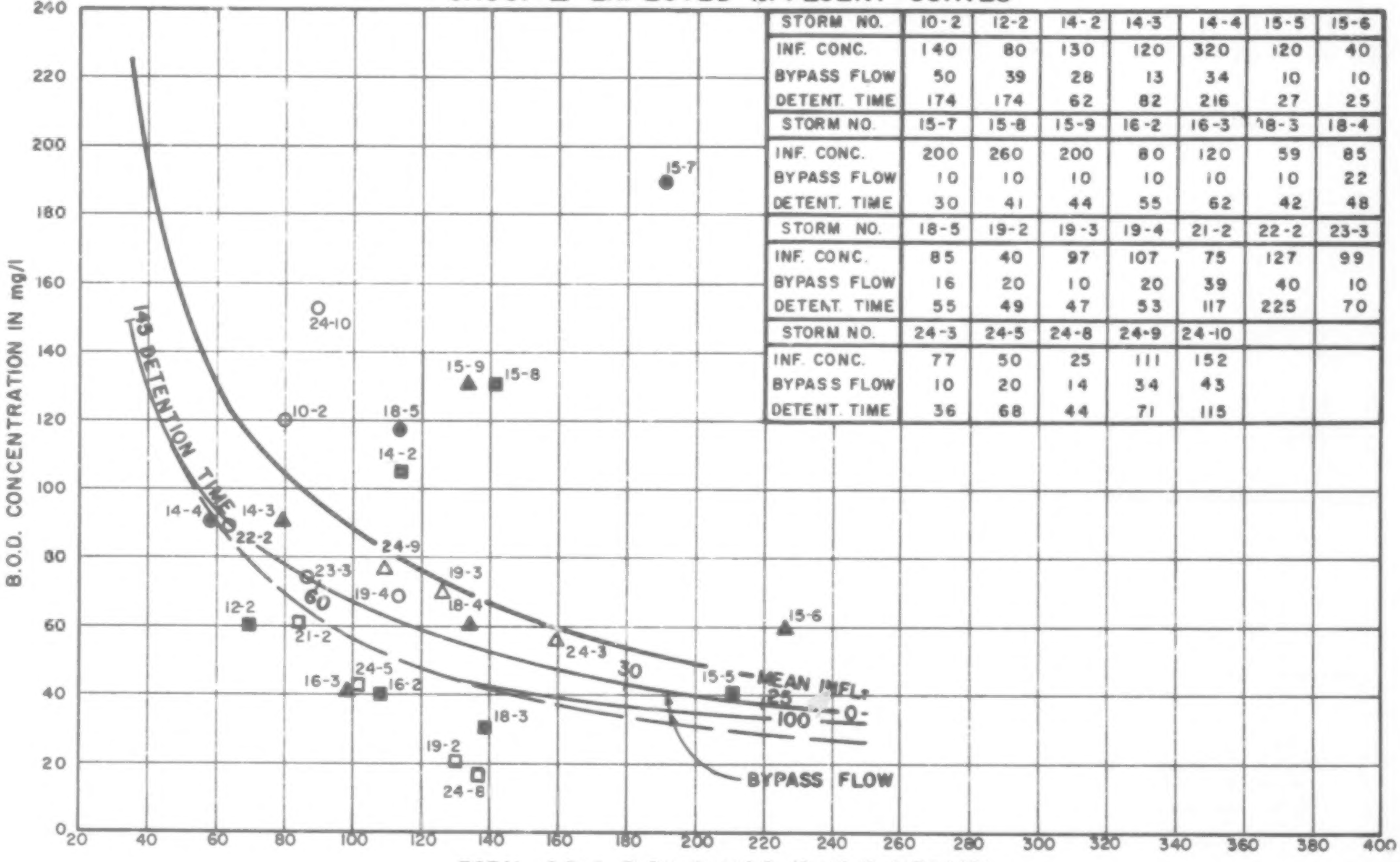


STORM NO.	9	10-1	11	12-1	13	14-1	15-1	15-2	15-3	15-4	16-1	17
INF. CONC.	125	250	185	130	100	100	180	100	160	120	80	160
BYPASS FLOW	31	10	28	39	10	10	39	67	72	92	10	50
DETENT TIME	74	55	74	56	38	28	76	17	61	28	28	98
STORM NO.	18-1	18-2	19-1	20	21-1	22-1	23-1	23-2	24-1	24-2	24-4	24-7
INF. CONC.	104	74	56	66	117	97	55	59	70	51	68	35
BYPASS FLOW	31	204	79	10	39	42	83	136	26	225	31	151
DETENT. TIME	31	30	19	27	80	58	38	69	49	32	31	25

FIGURE 45

B.O.D. CONCENTRATION VS. TOTAL Q.S.I.S. FLOW

GROUP II EXPECTED EFFLUENT CURVES



STORM NO.	10-2	12-2	14-2	14-3	14-4	15-5	15-6
INF. CONC.	140	80	130	120	320	120	40
BYPASS FLOW	50	39	28	13	34	10	10
DETENT. TIME	174	174	62	82	216	27	25
STORM NO.	15-7	15-8	15-9	16-2	16-3	18-3	18-4
INF. CONC.	200	260	200	80	120	59	85
BYPASS FLOW	10	10	10	10	10	10	22
DETENT. TIME	30	41	44	55	62	42	48
STORM NO.	18-5	19-2	19-3	19-4	21-2	22-2	23-3
INF. CONC.	85	40	97	107	75	127	99
BYPASS FLOW	16	20	10	20	39	40	10
DETENT. TIME	55	49	47	53	117	225	70
STORM NO.	24-3	24-5	24-8	24-9	24-10		
INF. CONC.	77	50	25	111	152		
BYPASS FLOW	10	20	14	34	43		
DETENT. TIME	36	68	44	71	115		

FIGURE 46

B.O.D CONCENTRATION VS. TOTAL O.S.I.S. FLOW

GROUP A INFLUENT SAMPLES

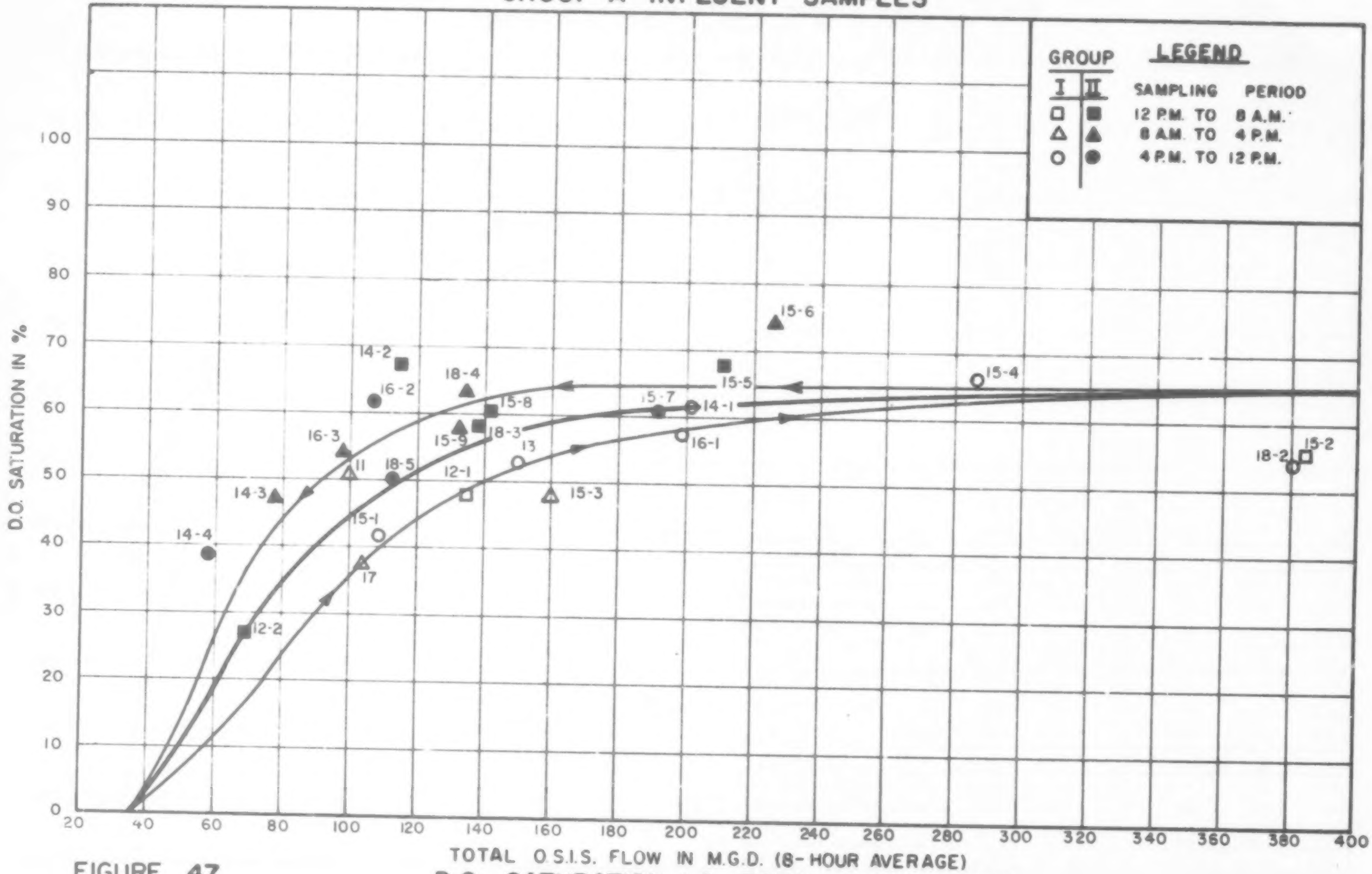


FIGURE 47

D.O. SATURATION VS. TOTAL O.S.I.S. FLOW

GROUP B INFLUENT SAMPLES

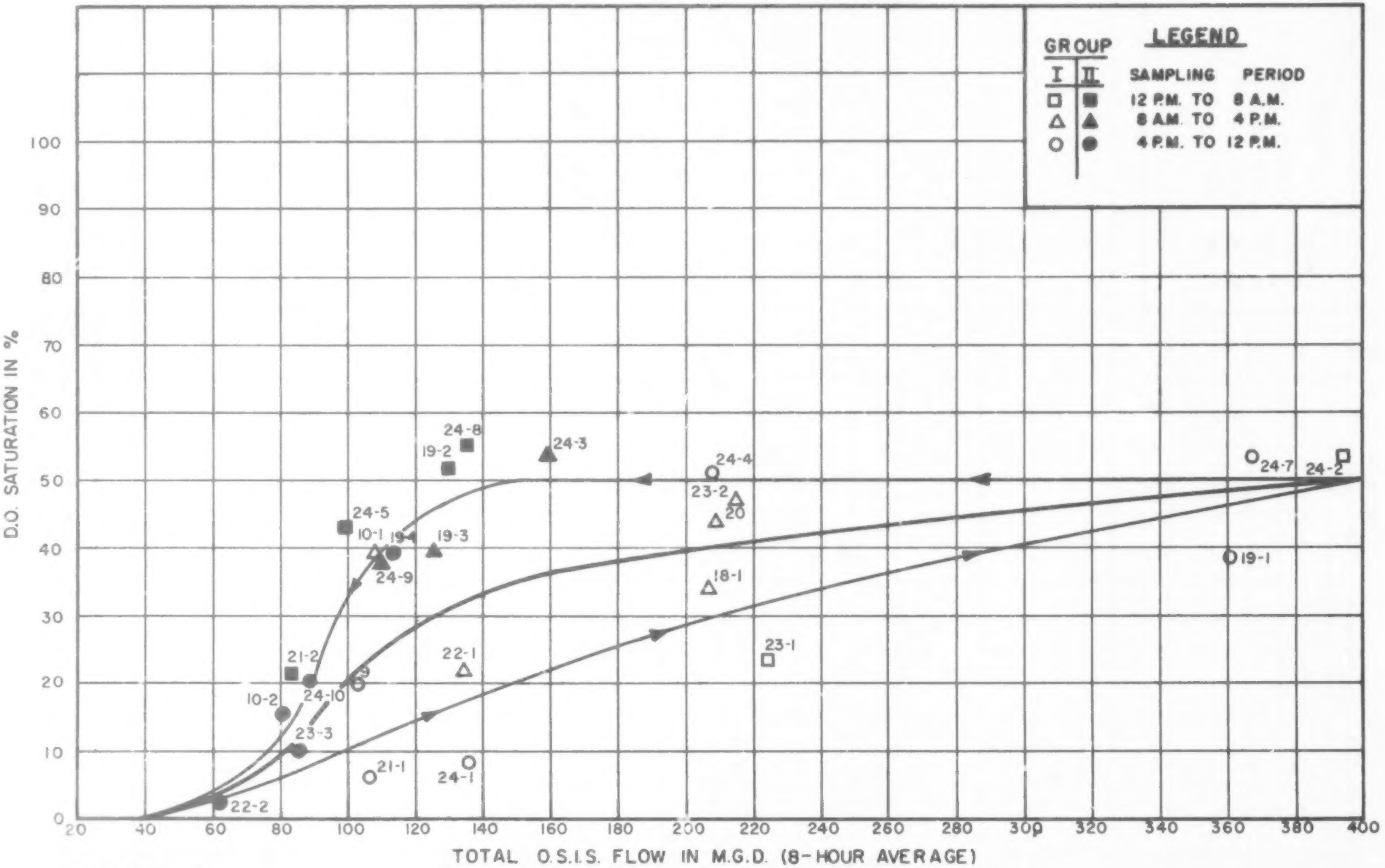


FIGURE 48

D.O. SATURATION VS. TOTAL O.S.I.S. FLOW

GROUP A & B

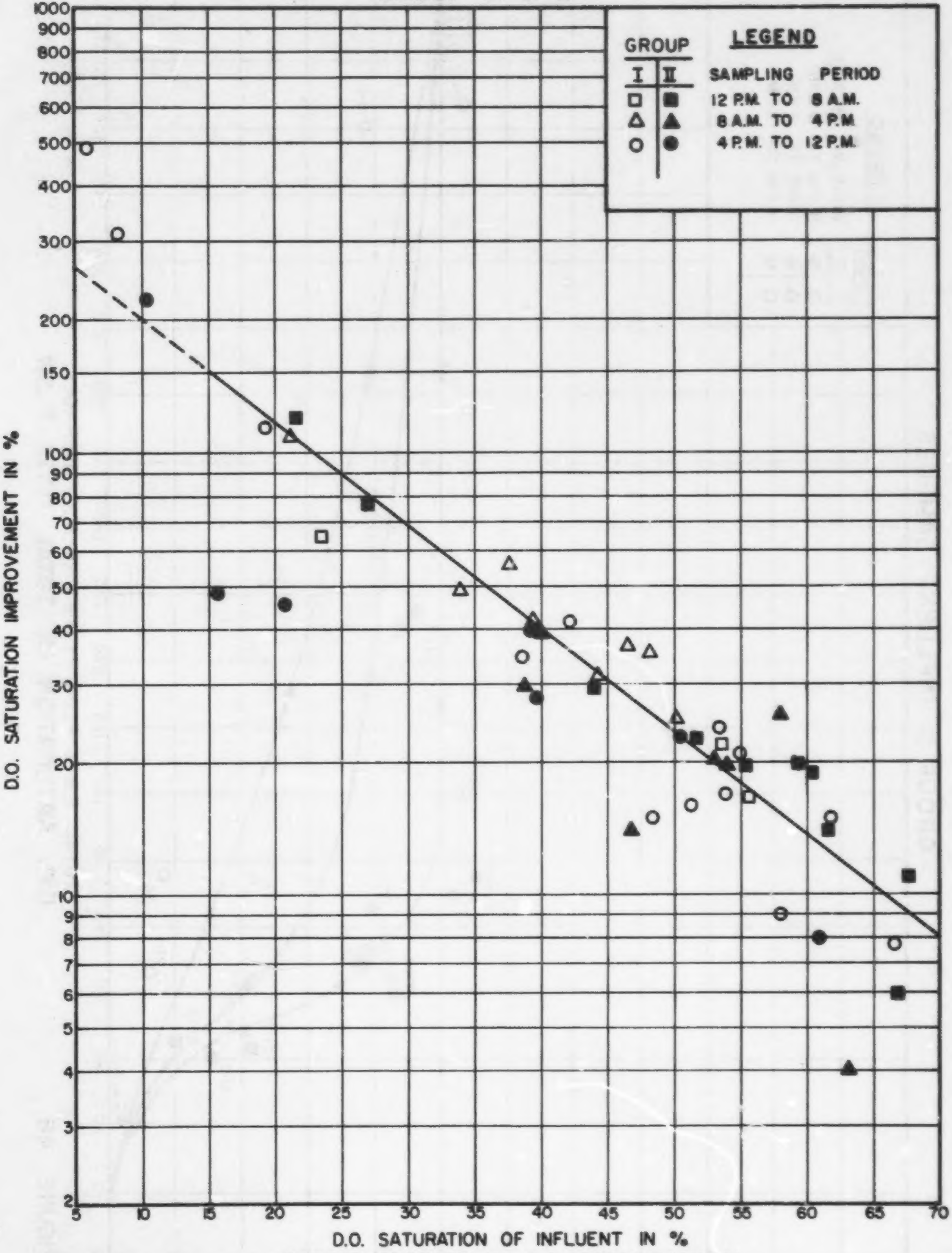


FIGURE 49 IMPROVEMENT IN D.O. SATURATION VS. D.O. SATURATION OF INFLUENT

GROUP A EXPECTED EFFLUENT CURVES

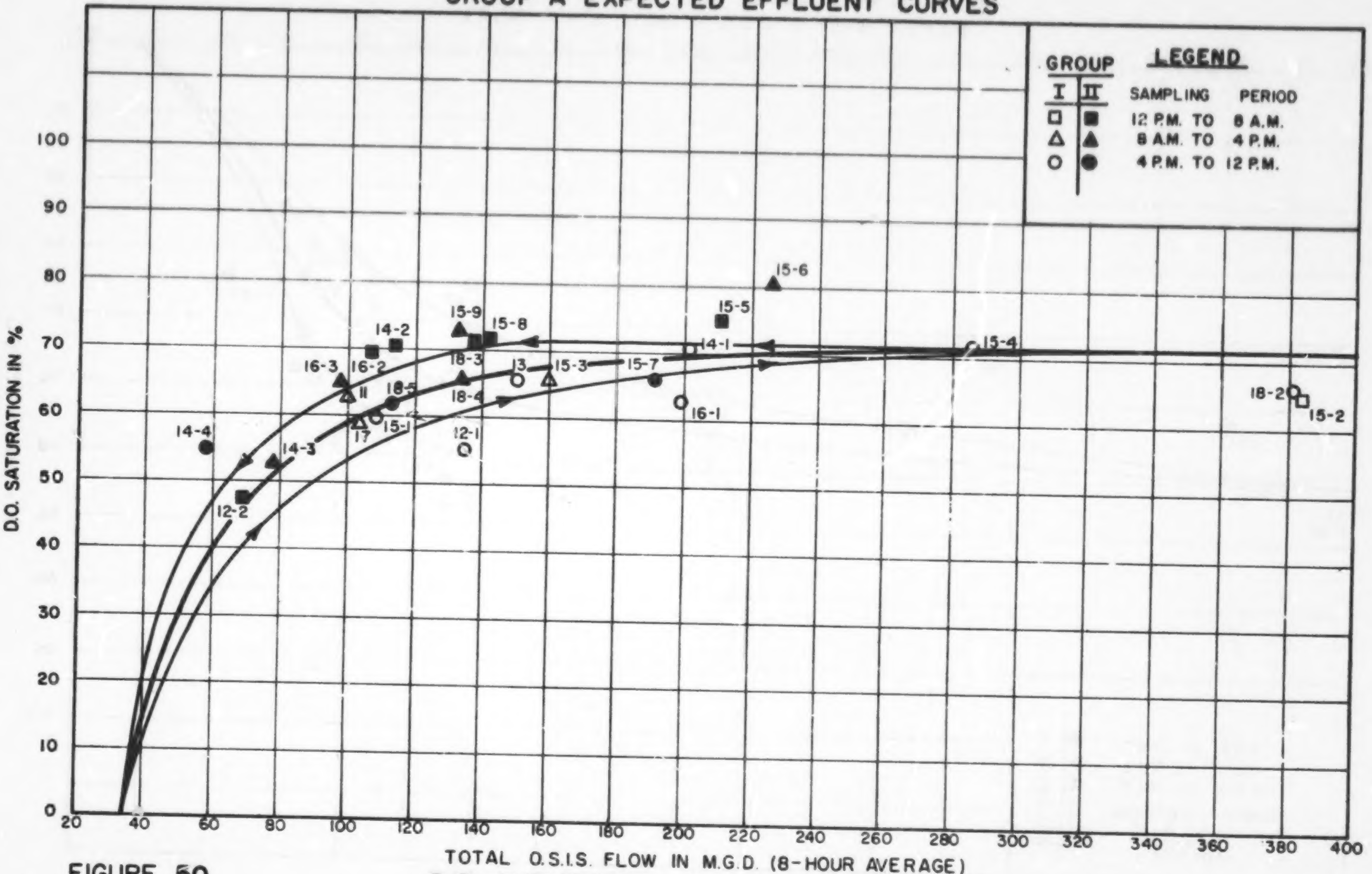


FIGURE 50

D.O. SATURATION VS. TOTAL O.S.I.S. FLOW

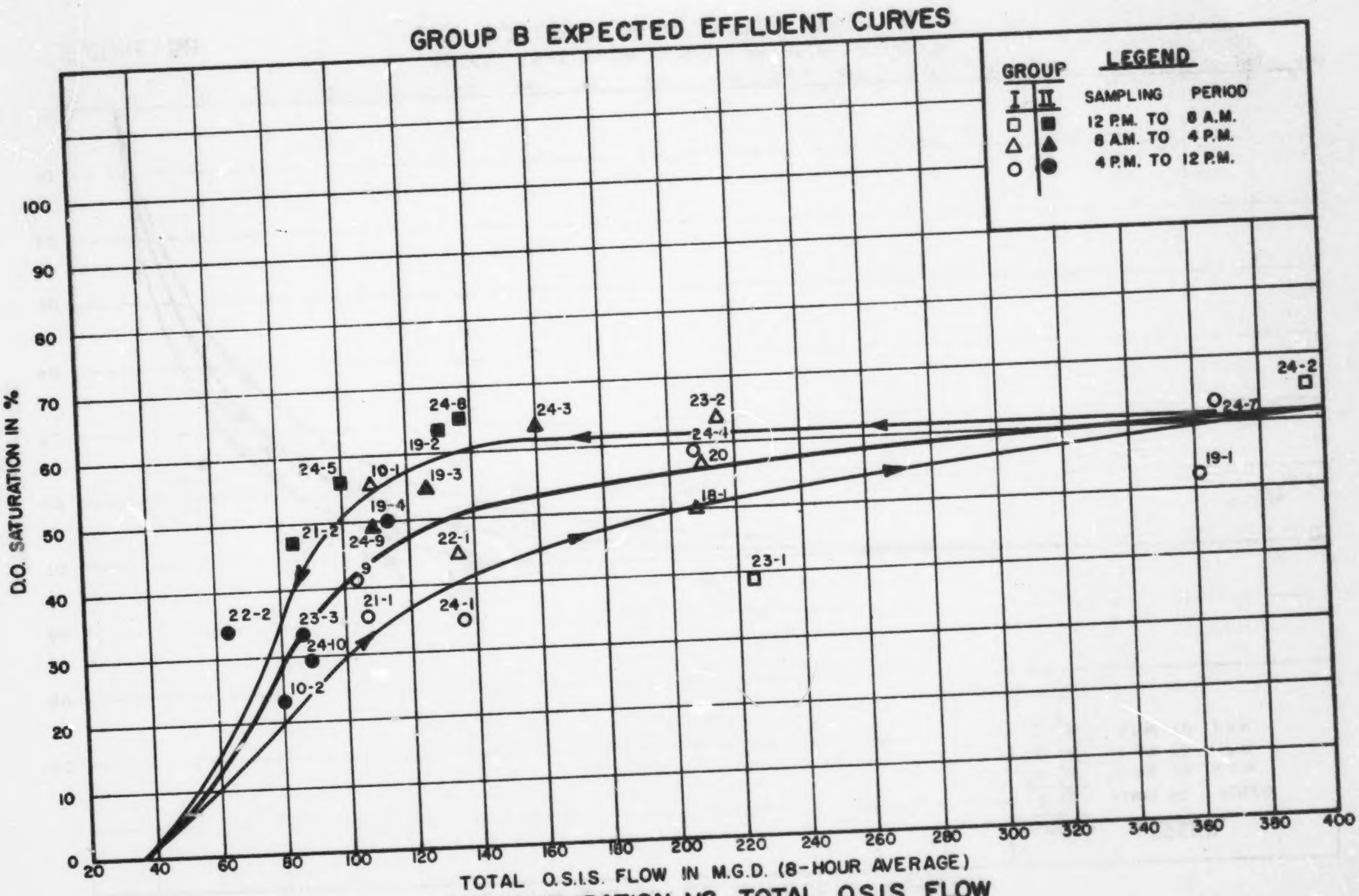


FIGURE 51

D.O. SATURATION VS. TOTAL O.S.I.S. FLOW

SECTION IX

ACKNOWLEDGMENTS

The contractor is greatly indebted to the following organizations and individuals for their assistance and cooperation during the studies for this report.

* * * * * * *

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Mr. George Eagle, Chief Engineer

City of Columbus

Mr. Warren J. Cremean, Public Service Director
Mr. C. E. Bischoff, Assistant Service Director
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Mr. Ray Klingbeil, Plant Manager
Mr. Morgan Cochran, Chief Chemist
All Jackson Pike Waste Treatment Plant Operators who promptly advised the contractor when the tanks would go into operation

Columbus Water and Chemical Testing Laboratory

Mr. F. J. McIntyre

APPENDIX A

RESULTS OF LABORATORY TESTS

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WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 1		No. 2	
Date	May 9,1968 Thurs		May 11,1968 Sat.	
Sampling Period	1:45 PM-3:45 PM		11:15 AM-10:45 PM	
Sampling Interval	1/2 Hour		1/2 Hour	
Composite Sample	**Influent**	**Effluent**	**Influent**	**Effluent**
Total Solids	508	400	504	458
Volatile Solids	190	114	174	114
Fixed Solids	318	286	330	344
Total Suspended Solids	148	80	126	106
Volatile Solids	92	46	80	52
Fixed Solids	56	34	46	54
Settleable Solids (ml/1)	Insufficient Sample		2.0	1.4
Ether Soluble	32	9	28	23
Coli (MPN)	71,600	71,600	71,600	71,600
B.O.D. 5 days @ 20° C	320	120	270	60
Temperature (°C)	17.7	17.5	16.4	16.3
Dissolved Oxygen (D.O.)	3.3	4.4	4.3	5.0
D.O. % Saturated	34.1	45.2	43.5	58.3
pH Value	7.4	7.8	7.7	7.7

Storm	No. 3		No. 4	
Date	May 16,1968 Thurs		May 18,1968 Sat.	
Sampling Period	8:30 AM-10:30 AM		8:00 AM-3:30 PM	
Sampling Interval	1/2 Hour		1/2 Hour	
Composite Sample	**Influent**	**Effluent**	**Influent**	**Effluent**
Total Solids	492	382	464	392
Volatile Solids	198	154	298	150
Fixed Solids	294	228	166	242
Total Suspended Solids	152	80	94	54
Volatile Solids	72	34	64	36
Fixed Solids	80	46	30	18
Settleable Solids (ml/1)	1.5	0.2	1.6	0.3
Ether Soluble	16	4	17	18
Coli (MPN)	71,600	71,600	71,600	71,600
B.O.D. 5 days @ 20° C	80	35	80	12.5
Temperature (°C)	18.0	18.0	15.8	15.4
Dissolved Oxygen (D.O.)	5.0	6.2	4.0	6.1
D.O. % Saturated	57.0	64.7	39.9	60.3
pH Value	7.5	7.4	7.6	7.6

Notes for all sheets:

Values under Composite Sample and Dissolved Oxygen are in milligrams per liter, except where otherwise shown

Values for D.O., D.O. % Saturated, Temperature, and pH are average of all samples in period

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WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 5-1		No. 5-2	
Date	May 23,1968 Thurs		May 23&24,1968 Th&Fr	
Sampling Period	8:30 AM-4:30 PM		5:00 PM-8:00 AM	
Sampling Interval	1/2 Hour		1 Hour	
Composite Sample	**Influent**	**Effluent**	**Influent**	**Effluent**
Total Solids	436	402	528	512
Volatile Solids	166	132	180	184
Fixed Solids	270	270	348	328
Total Suspended Solids	158	160	114	118
Volatile Solids	76	68	56	38
Fixed Solids	82	92	58	80
Settleable Solids (ml/1)	2.2	2.4	1.3	1.0
Ether Soluble	26	18	2	2
Coli (MPN)	71,600	71,600	71,600	71,600
B.O.D. 5 days @ 20° C	160	62.5	160	27.5
Temperature (°C)	15.3	15.3	16.0	16.0
Dissolved Oxygen (D.O.)	5.2	5.1	6.6	6.7
D.O. % Saturated	52.2	51.3	66.6	67.3
pH Value	7.3	7.3	7.4	7.35

Storm	No. 5-3		No. 5-4	
Date	May 24,1968 Fri		May 24,1968 Fri	
Sampling Period	10:00 A.M.-4:00 PM		6 PM-12:00 M	
Sampling Interval	2 Hour		2 Hour	
Composite Sample	**Influent**	**Effluent**	**Influent**	**Effluent**
Total Solids	650	640	700	734
Volatile Solids	258	260	296	326
Fixed Solids	392	380	404	408
Total Suspended Solids	286	82	84	56
Volatile Solids	58	62	64	50
Fixed Solids	228	20	20	6
Settleable Solids (ml/1)	2.5	2.0	1.7	1.4
Ether Soluble	12	10	27	6
Coli (MPN)	71,600	71,600	71,600	71,600
B.O.D. 5 days @ 20° C	180	38	140	24
Temperature (°C)	16.6	16.6	17.0	17.0
Dissolved Oxygen (D.O.)	5.4	6.1	4.6	5.6
D. O. % Saturated	55.5	62.6	47.2	57.5
pH Value	7.4	7.4	7.5	7.4

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 5-5		No. 5-6	
Date	May 25, 1968 Sat.		May 25, 1968 Sat.	
Sampling Period	2:00 AM-8:00 AM		10:00 AM-4:00 PM	
Sampling Interval	2 Hours		2 Hours	
Composite Sample	Influent	Effluent	Influent	Effluent
Total Solids	706	696	774	746
Volatile Solids	286	262	274	274
Fixed Solids	420	434	500	472
Total Suspended Solids	62	52	122	58
Volatile Solids	44	38	86	50
Fixed Solids	18	14	36	8
Settleable Solids (ml/l)	1.4	0.6	2.1	0.6
Ether Soluble	6	4	20	9
Coli (MPN)	71,600	71,600	71,600	71,600
B.O.D. 5 days @ 20° C	80	28	80	36
Temperature (°C)	16.2	16.2	16.9	16.9
Dissolved Oxygen (D.O.)	5.8	6.7	4.9	5.5
D.O. % Saturated	59.1	68.1	49.9	56.6
pH Value	7.4	7.5	7.5	7.5

Storm	No. 5-7		No. 5-8	
Date	May 25,1968 Sat.		May 26,1968 Sun.	
Sampling Period	6:00 PM-12:00 M		2:00 AM-6:00 AM	
Sampling Interval	2 Hours		2 Hours	
Composite Sample	Influent	Effluent	Influent	Effluent
Total Solids	764	714	808	770
Volatile Solids	258	254	364	312
Fixed Solids	506	460	444	458
Total Suspended Solids	122	68	78	52
Volatile Solids	100	56	68	44
Fixed Solids	22	12	10	8
Settleable Solids (ml/l)	2.0	0.4	1.8	Trace
Ether Soluble	21	15	18	14
Coli (MPN)	71,600	71,600	71,600	71,600
B.O.D. 5 days @ 20° C	140	66	60	46
Temperature (°C)	17.7	17.9	17.2	17.2
Dissolved Oxygen (D.O.)	3.8	4.5	2.8	3.7
D. O. % Saturated	40.2	47.0	28.8	37.8
pH Value	7.4	7.4	7.3	7.4

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 6-1		No. 6-2	
Date	May 28, 1968 Tues		May 28&29,1968 Tu&Wed.	
Sampling Period	3:00 PM-9:00 PM		11:00 PM-5:00 AM	
Sampling Interval	2 Hours		2 Hours	
Composite Sample	Influent	Effluent	Influent	Effluent
Total Solids	708	696	698	714
Volatile Solids	236	230	220	246
Fixed Solids	472	466	478	468
Total Suspended Solids	102	82	122	82
Volatile Solids	88	70	96	64
Fixed Solids	14	12	26	18
Settleable Solids (ml/l)	2.4	1.8	2.2	2.0
Ether Soluble	11	8	3	10
Coli (MPN)	71,600	71,600	71,600	71,600
B.O.D. 5 days @ 20° C	100	62	60	46
Temperature (°C)	17.0	17.0	17.0	17.0
Dissolved Oxygen (D.O.)	4.5	5.2	4.2	5.3
D.O. % Saturated	46.2	53.5	43.1	54.9
pH Value	7.7	7.4	7.2	7.3

Storm	No. 6-3		No. 7	
Date	May 29,1968 Wed.		July 19&20,1968 Fr&Sat.	
Sampling Period	7:00 AM-1:00 PM		11:00 PM-12:30 AM	
Sampling Interval	2 hours		1/2 Hour	
Composite Sample	Influent	Effluent	Influent	Effluent
Total Solids	774	774	426	426
Volatile Solids	284	310	148	140
Fixed Solids	490	464	278	286
Total Suspended Solids	81	86	244	218
Volatile Solids	54	64	72	72
Fixed Solids	27	22	172	146
Settleable Solids (ml/l)	1.5	1.8	2.0	1.5
Ether Soluble	12	12	19	15
Coli (MPN)	71,600	71,600	71,600	71,600
B.O.D. 5 days @ 20° C	180	50	100	52
Temperature (°C)	17.0	17.0	24.4	24.7
Dissolved Oxygen (D.O.)	4.6	5.5	3.2	3.6
D. O. % Saturated	47.6	56.8	37.1	43.3
pH Value	7.4	7.4	6.9	7.0

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 8		No. 9	
Date	Aug 7,1968 Wed.		Nov 7&8,1968 Th&Fr	
Sampling Period	5:00 PM-6:30 PM		2:30 PM-1:00 AM	
Sampling Interval	1/2 Hour		1/2 Hour	
Composite Sample	**Influent**	**Effluent**	**Influent**	**Effluent**
Total Solids	342	304	498	520
Volatile Solids	128	102	236	276
Fixed Solids	214	202	262	244
Total Suspended Solids	86	84	154	134
Volatile Solids	50	58	102	78
Fixed Solids	36	26	52	56
Settleable Solids (ml/l)	0.3	0.4	1.4	0.7
Ether Soluble	2	3	22	14
Coli (MPN)	71,600	71,600	71,600	71,600
B.O.D. 5 days @ 20° C	40	65	125	100
Temperature (°C)	26.0	26.0	16.1	16.2
Dissolved Oxygen (D.O.)	1.9	3.25	2.0	4.1
D.O. % Saturated	22.5	39.5	19.4	41.5
pH Value	7.35	7.35	7.2	7.2

Storm	No. 10-1		No. 10-2	
Date	Nov 16,1968 Sat.		Nov 16,1968 Sat.	
Sampling Period	9:30 AM-5:00 PM		6:00 PM-9:00 PM	
Sampling Interval	1/2 Hour		1 Hour	
Composite Sample	**Influent**	**Effluent**	**Influent**	**Effluent**
Total Solids	458	376	568	480
Volatile Solids	154	112	196	140
Fixed Solids	304	264	372	340
Total Suspended Solids	128	52	90	108
Volatile Solids	52	22	58	78
Fixed Solids	76	30	32	30
Settleable Solids (ml/l)	2.1	0.1	1.5	1.0
Ether Soluble	21	12	10	10
Coli (MPN)	71,600	71,600	71,600	71,600
B.O.D. 5 days @ 20° C	250	115	140	120
Temperature (°C)	15.1	14.6	17.0	16.9
Dissolved Oxygen (D.O.)	4.0	5.8	1.6	2.3
D.O. % Saturated	39.5	56.2	15.9	23.5
pH Value	7.3	7.3	7.2	7.2

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 11		No. 12-1	
Date	Dec 19,1968 Thurs		Dec 22,1968 Sun.	
Sampling Period	10:00 AM-3:30 PM		2:30 PM-10:00 PM	
Sampling Interval	1/2 Hour		1/2 Hour	
Composite Sample	**Influent**	**Effluent**	**Influent**	**Effluent**
Total Solids	648	518	442	350
Volatile Solids	292	204	208	140
Fixed Solids	356	314	234	210
Total Suspended Solids	195	120	138	112
Volatile Solids	108	86	74	44
Fixed Solids	87	34	64	68
Settleable Solids (ml/1)	1.5	0.3	2.3	0.4
Ether Soluble	32.8	16.0	22.4	13.6
Coli (MPN)	71,600	71,600	71,600	71,600
B.O.D. 5 days @ 20° C	185	200	130	125
Temperature (°C)	11.5	11.7	10.6	10.0
Dissolved Oxygen (D.O.)	5.5	7.0	5.45	6.3
D.O. % Saturdated	50.2	62.6	48.4	55.7
pH Value	7.3	7.4	7.0	7.0

Storm	No. 12-2		No. 13	
Date	Dec 22&23,1968 Sun.		Dec 27,1968 Fri	
Sampling Period	11:00 PM-1:00 AM		4:00 PM-6:30 PM	
Sampling Interval	1 Hour		1/2 Hour	
Composite Sample	**Influent**	**Effluent**	**Influent**	**Effluent**
Total Solids	432	350	460	412
Volatile Solids	132	88	206	162
Fixed Solids	300	262	254	250
Total Suspended Solids	72	40	194	186
Volatile Solids	56	26	102	82
Fixed Solids	16	14	92	104
Settleable Solids (ml/1)	0.6	Trace	2.0	1.3
Ether Soluble	16.4	5.6	20.8	16.0
Coli (MPN)	71,600	71,600	71,600	71,600
B.O.D. 5 days @ 20° C	80	60	100	90
Temperature (°C)	13.2	12.0	9.1	8.3
Dissolved Oxygen (D.O.)	2.9	5.2	6.2	7.7
D.O. % Saturated	27.1	47.9	53.3	66.1
pH Value	7.1	7.2	7.1	7.3

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 14-1		No. 14-2	
Date	Jan 17&18,1969 Fri&Sat.		Jan 18,1969 Sat.	
Sampling Period	8:30 PM-4:00 AM		5:00 AM-12:00 N	
Sampling Interval	1/2 Hour		1 Hour	
Composite Sample	**Influent**	**Effluent**	**Influent**	**Effluent**
Total Solids	514	480	536	448
Volatile Solids	250	240	220	148
Fixed Solids	264	240	316	300
Total Suspended Solids	222	226	94	86
Volatile Solids	104	98	46	54
Fixed Solids	118	128	48	32
Settleable Solids (ml/1)	2.5	2.0	1.1	1.0
Ether Soluble	16.0	16.8	8.4	10.4
B.O.D. 5 days @ 20° C	100	120	130	105
Temperature (°C)	8.3	8.3	10.0	9.8
Dissolved Oxygen (D.O.)	7.3	8.3	7.6	8.0
D. O. % Saturated	61.8	71.1	66.8	70.7
pH Value	7.0	7.0	7.0	7.0

Storm	No. 14-3		No. 14-4	
Date	Jan 18,1969 Sat.		Jan 18&19,1969 Sat.&Sun.	
Sampling Period	1:00 PM-8:00 PM		10:00 PM-4:00 AM	
Sampling Interval	1 Hour		2 Hours	
Composite Sample	**Influent**	**Effluent**	**Influent**	**Effluent**
Total Solids	644	614	676	572
Volatile Solids	290	278	264	150
Fixed Solids	354	336	412	422
Total Suspended Solids	114	82	108	60
Volatile Solids	84	58	100	48
Fixed Solids	30	24	8	12
Settleable Solids (ml/1)	2.0	0.7	2.0	Trace
Ether Soluble	22.8	19.2	26.0	16.4
B.O.D. 5 days @ 20° C	120	90	320	90
Temperature (°C)	12.0	12.1	13.0	12.5
Dissolved Oxygen (D.O.)	5.1	5.8	4.2	5.9
D.O. % Saturated	46.9	53.3	39.2	54.9
pH Value	7.1	7.1	7.1	7.1

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 15-1		No. 15-2	
Date	Jan 28, 1969 Tues		Jan 29, 1969 Wed.	
Sampling Period	4:00 PM-11:30 PM		12:30 AM-7:30 AM	
Sampling Interval	1/2 Hour		1/2 Hour	
Composite Sample	**Influent**	**Effluent**	**Influent**	**Effluent**
Total Solids	630	502	620	462
Volatile Solids	268	180	108	298
Fixed Solids	362	322	512	164
Total Suspended Solids	250	132	300	278
Volatile Solids	136	62	100	180
Fixed Solids	114	70	200	98
Settleable Solids (ml/l)	2.5	0.6	2.5	1.5
Ether Soluble	30.0	16.0	28.0	17.2
B.O.D. 5 days @ 20° C	180	100	100	120
Temperature (°C)	10.3	9.5	9.9	9.8
Dissolved Oxygen (D.O.)	4.8	6.9	6.4	7.5
D.P. % Saturated	42.3	60.2	55.6	65.3
pH Value	6.9	7.0	7.1	7.1

Storm	No. 15-3		No. 15-4	
Date	Jan 29,1969 Wed.		Jan 29,1969 Wed.	
Sampling Period	8:30 AM-3:30 PM		4:30 PM-10:30 PM	
Sampling Interval	1/2 Hour		2 Hours	
Composite Sample	**Influent**	**Effluent**	**Influent**	**Effluent**
Total Solids	582	598	270	428
Volatile Solids	216	226	164	178
Fixed Solids	366	372	106	250
Total Suspended Solids	152	100	176	192
Volatile Solids	92	56	76	60
Fixed Solids	60	44	100	132
Settleable Solids (ml/l)	1.9	1.0	2.0	1.0
Ether Soluble	25.6	10.8	17.2	15.2
B.O.D. 5 days @ 20° C	160	60	120	40
Temperature (°C)	11.6	11.2	10.9	10.8
Dissolved Oxygen (D.O.)	5.3	7.3	7.4	8.0
D. O. % Saturated	48.2	65.5	66.8	71.9
pH Value	7.1	6.8	7.0	7.1

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 15-5		No. 15-6	
Date	Jan 30,1969 Thurs		Jan 30,1969 Thurs	
Sampling Period	12:30 AM-6:30 AM		8:30 AM-2:30 PM	
Sampling Interval	2 Hours		2 Hours	
Composite Sample	**Influent**	**Effluent**	**Influent**	**Effluent**
Total Solids	484	518	532	530
Volatile Solids	70	252	236	232
Fixed Solids	414	266	296	298
Total Suspended Solids	90	150	82	84
Volatile Solids	76	46	54	56
Fixed Solids	14	104	28	28
Settleable Solids (ml/1)	0.9	0.7	1.6	1.6
Ether Soluble	14.2	5.6	7.2	10.8
B.O.D. 5 days @ 20° C	120	40	40	60
Temperature (°C)	11.0	11.0	11.6	11.8
Dissolved Oxygen (D.O.)	7.5	8.3	8.1	8.7
D. O. % Saturated	67.8	75.1	74.1	80.0
pH Value	7.2	7.0	7.2	6.9

Storm	No. 15-7		No. 15-8	
Date	Jan 30,1969 Thurs		Jan 31,1969 Fri	
Sampling Period	4:30 PM-10:30 PM		12:30 AM-6:30 AM	
Sampling Interval	2 Hours		2 Hours	
Composite Sample	**Influent**	**Effluent**	**Influent**	**Effluent**
Total Solids	570	772	694	628
Volatile Solids	264	416	300	254
Fixed Solids	306	366	394	374
Total Suspended Solids	96	104	76	72
Volatile Solids	70	46	62	62
Fixed Solids	26	58	14	10
Settleable Solids (ml/1)	0.5	0.6	0.3	0.3
Ether Soluble	17.6	16.8	13.2	8.8
B.O.D. 5 days @ 20° C	200	190	260	130
Temperature (°C)	12.0	12.0	12.0	12.0
Dissolved Oxygen (D.O.)	6.6	7.1	6.6	7.8
D. O. % Saturated	60.9	65.5	60.5	71.9
pH Value	7.0	7.2	7.2	7.3

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 15-9	No. 16-1
Date	Jan 31,1969 Fri	Feb 8&9,1969 Sat.&Sun.
Sampling Period	8:30 AM-2:30 PM	6:00 PM-1:30 AM
Sampling Interval	2 Hours	1/2 Hour

Composite Sample	Influent	Effluent	Influent	Effluent
Total Solids	726	686	408	444
Volatile Solids	312	260	178	192
Fixed Solids	414	426	230	252
Total Suspended Solids	100	76	156	208
Volatile Solids	76	62	52	88
Fixed Solids	24	14	104	120
Settleable Solids (ml/1)	0.7	0.4	1.3	1.3
Ether Soluble	18.4	14.4	12.4	13.2
B.O.D. 5 days @ 20° C	200	130	80.0	60.0
Temperature (°C)	12.6	12.5	9.1	9.1
Dissolved Oxygen (D.O.)	6.2	7.9	6.7	7.3
D.O. % Saturated	58.0	73.2	58.1	63.4
pH Value	7.2	7.4	6.7	6.8

Storm	No. 16-2	No. 16-3
Date	Feb 9,1969 Sun.	Feb 9,1969 Sun.
Sampling Period	2:00 AM-9:00 AM	10:00 AM-5:00 PM
Sampling Interval	1 Hour	1 Hour

Composite Sample	Influent	Effluent	Influent	Effluent
Total Solids	410	578	620	598
Volatile Solids	118	182	204	190
Fixed Solids	292	396	416	408
Total Suspended Solids	52	58	68	44
Volatile Solids	26	28	40	22
Fixed Solids	26	30	28	22
Settleable Solids (ml/1)	0.1	0.2	0.2	0.2
Ether Soluble	6.4	8.0	17.2	14
B.O.D. 5 days @ 20° C	80.0	40.0	120.0	40.0
Temperature (°C)	10.7	10.7	11.6	11.6
Dissolved Oxygen (D.O.)	6.9	8.1	5.9	7.1
D.O. % Saturated	61.6	70.1	53.9	64.7
pH Value	6.7	6.8	7.2	7.3

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 17
Date	March 24, 1969 Mon
Sampling Period	9:00 AM-4:30 PM
Sampling Interval	1/2 Hour

Composite Sample	Influent	Effluent
Total Solids	588	362
Volatile Solids	228	76
Fixed Solids	360	286
Total Suspended Solids	214	116
Volatile Solids	128	70
Fixed Solids	86	46
Settleable Solids (ml/l)	2.2	0.5
Ether Soluble	30	16
B.O.D. 5 days @ 20° C	160	80
B.O.D. on Settled Sample	120	70
Temperature (°C)	12.4	11.8
Dissolved Oxygen (D.O.)	3.9	6.5
D.O. % Saturated	37.7	59.2
pH Value	7.3	7.4

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 18-1
Date	April 18, 1969 Fri
Sampling Period	7:30 AM-3:00 PM
Sampling Interval	1/2 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	440	451	445	396	406	401
Volatile Solids	160	108	134	178	94	136
Fixed Solids	280	343	311	218	312	265
Total Suspended Solids	156	120	138	120	180	150
Volatile Solids	92	80	86	68	28	48
Fixed Solids	64	40	52	52	152	102
Settleable Solids (ml/l)	2.0	2.0	2.0	1.2	1.3	1.3
Ether Soluble	12	5	8.5	38	2	20.0
B.O.D. 5 days @ 20° C	140	68	104	50	47	48.0
B.O.D. on Settled Sample	80	-	-	40	-	-
Temperature (°C)	16.2	-	-	16.2	-	-
Dissolved Oxygen (D.O.)	3.4	-	-	5.1	-	-
D.O. % Saturated	33.9	-	-	50.4	-	-
pH Value	6.9	-	-	7.0	-	-

Storm	No. 18-2
Date	April 18, 1969 Fri
Sampling Period	4:00 PM-11:00 PM
Sampling Interval	1 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	538	409.5	474	438	438	438
Volatile Solids	224	136	180	210	87	148
Fixed Solids	314	273.5	294	228	351	290
Total Suspended Solids	322	292	307	212	280	246
Volatile Solids	122	64	93	86	36	61
Fixed Solids	200	228	214	126	244	185
Settleable Solids (ml/l)	3.0	3.0	3.0	1.2	1.7	1.5
Ether Soluble	16	18	17.0	15	35	25.0
B.O.D. 5 day @ 20° C	100	47	74	80	34	57
B.O.D. Settled Sample	40	-	-	30	-	-
Temperature (°C)	13.9	-	-	14.1	-	-
Dissolved Oxygen (D.O.)	5.7	-	-	6.9	-	-
D.O. % Saturated	54.9	-	-	66.4	-	-
pH Value	6.9	-	-	6.9	-	-

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 18-3
Date	April 19, 1969 Sat.
Sampling Period	12:00 AM-7:00 AM
Sampling Interval	1 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	532	519	525	550	536	543
Volatile Solids	198	77	137	262	104	183
Fixed Solids	334	442	388	288	432	360
Total Suspended Solids	48	88	68	54	62	58
Volatile Solids	44	12	28	40	17	28
Fixed Solids	4	76	40	14	45	30
Settleable Solids (ml/l)	0.4	0.75	0.6	0.7	1.0	0.9
Ether Soluble	12	9	10.5	11	32	21.5
B.O.D. 5 days @ 20° C	80	37	59	30	32	31
B.O.D. on Settled Sample	30	-	-	20	-	-
Temperature (°C)	13.9	-	-	13.9	-	-
Dissolved Oxygen (D.O.)	6.2	-	-	7.4	-	-
D.O. % Saturated	59.5	-	-	71.5	-	-
pH Value	7.1	-	-	7.2	-	-

Storm	No. 18-4
Date	April 19, 1969 Sat.
Sampling Period	8:00 AM-3:00 PM
Sampling Interval	1 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	624	555	590	646	563	605
Volatile Solids	290	125	208	276	120	198
Fixed Solids	334	430	382	370	443	407
Total Suspended Solids	66	86	76	72	90	81
Volatile Solids	58	30	44	58	32	45
Fixed Solids	8	56	32	14	58	36
Settleable Solids (ml/l)	0.3	1.6	1.0	0.1	1.0	0.6
Ether Soluble	15	54	34.5	13	50	31.5
B.O.D. 5 days @ 20° C	120	51	85	80	49	60
B.O.D. on Settled Sample	100	-	-	60	-	-
Temperature (°C)	13.9	-	-	13.8	-	-
Dissolved Oxygen (D.O.)	6.6	-	-	6.8	-	-
D.O. % Saturated	63.2	-	-	65.6	-	-
pH Value	7.3	-	-	7.3	-	-

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 18-5
Date	April 19, 1969 Sat.
Sampling Period	4:00 PM-11:00 PM
Sampling Interval	1 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	544	532	538	548	545	546
Volatile Solids	208	125	166	202	131	166
Fixed Solids	336	407	372	346	414	380
Total Suspended Solids	70	108	89	82	100	91
Volatile Solids	62	36	49	66	36	51
Fixed Solids	8	72	40	16	64	40
Settleable Solids (ml/l)	0.3	1.8	1.1	0.1	1.7	0.9
Ether Soluble	8	47	27.5	5	16	10.5
B.O.D. 5 days @ 20° C	100	69	85	160	71	116
B.O.D. on Settled Sample	50	-	-	70	-	-
Temperature (°C)	14.1	-	-	14.1	-	-
Dissolved Oxygen (D.O.)	5.3	-	-	6.4	-	-
D. O. % Saturated	50.6	-	-	62.0	-	-
pH Value	7.2	-	-	7.3	-	-

Storm	No. 19-1
Date	May 8&9, 1969 Thurs & Fri
Sampling Period	6:00 PM-1:00 AM
Sampling Interval	1/2 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	682	613	648	602	489	546
Volatile Solids	230	140	185	218	101	160
Fixed Solids	452	473	463	384	388	386
Total Suspended Solids	358	310	334	254	300	277
Volatile Solids	132	25	79	104	75	90
Fixed Solids	226	285	255	150	225	187
Settleable Solids (ml/l)	2.1	2.5	2.3	1.3	1.4	1.4
Ether Soluble	14	5.6	9.8	10	3.6	6.8
B.O.D. 5 days @ 20° C	70	42	56	50	29	40
B.O.D. on Settled Sample	30	-	-	30	-	-
Temperature (°C)	17.9	-	-	17.9	-	-
Dissolved Oxygen (D.O.)	3.7	-	-	5.0	-	-
D.O. % Saturated	38.7	-	-	52.2	-	-
pH Value	6.8	-	-	6.8	-	-

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 19-2
Date	May 9, 1969 Fri
Sampling Period	2:00 AM-9:00 AM
Sampling Interval	1 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	606	610	608	526	547	537
Volatile Solids	254	147	200	180	110	145
Fixed Solids	352	463	408	346	437	392
Total Suspended Solids	96	136	116	84	64	74
Volatile Solids	52	24	38	62	11	37
Fixed Solids	44	112	78	22	53	37
Settleable Solids (ml/1)	1.5	1.2	1.4	0.7	0.8	0.8
Ether Soluble	8.4	4.4	6.4	8.4	6.4	7.4
B.O.D. 5 days @ 20° C	50	29	40	25	16	21
B.O.D. on Settled Sample	30	-	-	20	-	-
Temperature (°C)	16.6	-	-	16.5	-	-
Dissolved Oxygen (D.O.)	5.1	-	-	6.3	-	-
D.O. % Saturated	51.8	-	-	63.8	-	-
pH Value	6.7	-	-	6.9	-	-

Storm	No. 19-3
Date	May 9, 1969 Fri
Sampling Period	10:00 AM-5:00 PM
Sampling Interval	1 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	642	672	657	556	619	588
Volatile Solids	242	186	214	172	150	161
Fixed Solids	400	486	443	384	469	427
Total Suspended Solids	134	154	144	84	118	101
Volatile Solids	104	66	85	54	40	47
Fixed Solids	30	88	59	30	78	54
Settleable Solids (ml/1)	3.0	2.0	2.5	1.8	0.9	1.35
Ether Soluble	25.6	5.6	15.6	17.6	6.4	12.0
B.O.D. 5 days @ 20° C	120	74	97	80	60	70
B.O.D. on Settled Sample	45	-	-	70	-	-
Temperature (°C)	17.3	-	-	17.4	-	-
Dissolved Oxygen (D.O.)	3.9	-	-	5.4	-	-
D.O. % Saturated	39.7	-	-	55.4	-	-
pH Value	6.9	-	-	6.9	-	-

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	19-4
Date	May 9&10, 1969 Fri & Sat.
Sampling Period	6:00 PM-1:00 AM
Sampling Interval	1 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	694	722	708	666	666	666
Volatile Solids	224	185	205	222	152	187
Fixed Solids	470	537	503	444	514	479
Total Suspended Solids	116	152	134	92	102	97
Volatile Solids	86	68	77	74	24	49
Fixed Solids	30	84	57	18	78	48
Settleable Solids (ml/1)	2.0	1.6	1.8	0.4	0.45	0.4
Ether Soluble	24.8	7.2	16.0	18.8	2.8	10.8
B.O.D. 5 days @ 20° C	140	73	107	85	53	69
B.O.D. on Settled Sample	120	-	-	80	-	-
Temperature (°C)	17.1	-	-	17.1	-	-
Dissolved Oxygen (D.O.)	3.9	-	-	5.0	-	-
D. O. % Saturated	39.7	-	-	50.8	-	-
pH Value	6.6	-	-	6.7	-	-

Storm	No. 20
Date	May 19, 1969 Mon
Sampling Period	9:00 AM-4:30 PM
Sampling Interval	1/2 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	508	529	519	478	552	515
Volatile Solids	204	131	168	176	127	151
Fixed Solids	304	398	351	302	425	364
Total Suspended Solids	100	120	110	92	105	98
Volatile Solids	64	65	65	48	60	54
Fixed Solids	36	55	45	44	45	44
Settleable Solids (ml/1)	1.5	1.7	1.6	0.9	1.5	1.2
Ether Soluble	19.2	7.6	13.4	6.8	6.8	6.8
B.O.D. 5 days @ 20° C	70	61	66	45	46	46
B.O.D. on Settled Sample	40	-	-	15	-	-
Temperature (°C)	17.8	-	-	17.7	-	-
Dissolved Oxygen (D.O.)	4.3	-	-	5.5	-	-
D.O. % Saturated	44.3	-	-	57.3	-	-
pH Value	7.1	-	-	7.1	-	-

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 21-1
Date	June 2, 1969 Mon
Sampling Period	2:00 PM-9:30 PM
Sampling Interval	1/2 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	488	555	522	336	374	355
Volatile Solids	150	184	167	96	114	105
Fixed Solids	338	371	355	240	260	250
Total Suspended Solids	128	128	128	78	84	81
Volatile Solids	90	60	75	58	26	42
Fixed Solids	38	68	53	20	58	39
Settleable Solids (ml/1)	1.3	1.5	1.4	1.0	0.6	0.8
Ether Soluble	40	21	30.5	31	24	27.5
B.O.D. 5 days @ 20° C	150	84	117	80	46	63
B.O.D. on Settled Sample	130	-	-	35	-	-
Temperature (°C)	19.7	-	-	19.3	-	-
Dissolved Oxygen (D.O.)	0.6	-	-	3.3	-	-
D.O. % Saturated	6.1	-	-	35.6	-	-
pH Value	7.0	-	-	7.0	-	-

Storm	No. 21-2
Date	June 2, 1969 Mon
Sampling Period	10:30 PM-12:30 AM
Sampling Interval	1 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	420	460	440	416	440	428
Volatile Solids	126	153	140	116	128	122
Fixed Solids	294	307	300	300	312	306
Total Suspended Solids	114	130	122	108	88	98
Volatile Solids	68	50	59	52	36	44
Fixed Solids	46	80	63	56	52	54
Settleable Solids (ml/1)	1.0	1.4	1.2	0.3	0.9	0.6
Ether Soluble	25	16	20.5	21	20	20.5
B.O.D. 5 days @ 20° C	90	59	75	80	41	61
B.O.D. on Settled Sample	90	-	-	80	-	-
Temperature (°C)	19.0	-	-	19.0	-	-
Dissolved Oxygen (D.O.)	2.1	-	-	4.5	-	-
D.O. % Saturated	21.8	-	-	47.9	-	-
pH Value	6.9	-	-	7.0	-	-

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 22-1
Date	June 5, 1969 Thurs
Sampling Period	9:30 AM-4:30 PM
Sampling Interval	1 Hour

Composite Sample	Influent				Effluent			
	CW& CTL	State	City	Ave.	CW& CTL	State	City	Ave.
Total Solids	528	521	533	527	364	402	392	386
Volatile Solids	396	138	235	256	120	104	165	130
Fixed Solids	132	383	298	271	244	298	227	256
Total Suspended Solids	144	158	139	147	80	114	90	95
Volatile Solids	82	64	71	72	50	36	44	43
Fixed Solids	62	94	68	75	30	78	46	52
Settleable Solids (ml/1)	1.5	1.5	1.8	1.6	0.7	0.8	0.3	0.6
Ether Soluble	24	22	14	20.0	13	24	22	19.7
B.O.D. 5 days @ 20° C	110	84	97	97	80	45	62	62
B.O.D., Settled Sample	50	-	-	-	40	-	-	-
Temperature (°C)	18.5	-	-	-	18.0	-	-	-
Dissolved Oxygen (D.O.)	2.1	-	-	-	4.4	-	-	-
D.O. % Saturated	21.4	-	-	-	45.3	-	-	-
pH Value	7.0	-	-	-	7.1	-	-	-

Storm	No. 22-2
Date	June 5, 1969 Thurs
Sampling Period	5:30 PM-12:30 AM
Sampling Interval	1 Hour

Composite Sample	Influent				Effluent			
	CW& CTL	State	City	Ave.	CW& CTL	State	City	Ave.
Total Solids	630	662	664	652	554	574	560	563
Volatile Solids	204	163	260	209	194	142	190	175
Fixed Solids	426	499	404	443	360	432	370	388
Total Suspended Solids	88	94	80	87	72	88	62	74
Volatile Solids	74	64	59	66	52	36	44	44
Fixed Solids	14	30	21	21	20	52	18	30
Settleable Solids (ml/1)	0.6	1.0	0.3	0.6	0.1	0.5	0.1	0.2
Ether Soluble	30	27	12	23.0	28	27	16	23.7
B.O.D. 5 days @ 20° C	120	142	119	127	95	71	101	89
B.O.D., Settled Sample	100	-	-	-	65	-	-	-
Temperature (°C)	20.6	-	-	-	20.0	-	-	-
Dissolved Oxygen (D.O.)	0.3	-	-	-	3.2	-	-	-
D. O. % Saturated	2.8	-	-	-	34.6	-	-	-
pH Value	7.1	-	-	-	7.1	-	-	-

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 23-1
Date	June 12&13,1969 Thurs&Fri
Sampling Period	10:00 PM-5:00 AM
Sampling Interval	1 Hour

Composite Sample	Influent				Effluent			
	CW& CTL	State	City	Ave.	CW& CTL	State	City	Ave.
Total Solids	386	389	400	392	324	342	362	343
Volatile Solids	130	191	154	158	106	81	162	116
Fixed Solids	256	198	246	234	218	261	200	227
Total Suspended Solids	160	166	157	161	124	126	128	126
Volatile Solids	84	46	69	66	64	26	52	47
Fixed Solids	76	120	88	95	60	100	76	79
Settleable Solids (ml/1)	1.8	1.4	1.9	1.7	1.0	1.4	1.2	1.2
Ether Soluble	56	6.8	32	44.0*	39	56	13	26.0*
B.O.D. 5 days @ 20° C	40	52	74	55	30	40	56	42
B.O.D., Settled Sample	20	-	-	-	30	-	-	-
Temperature (°C)	20.9	-	-	-	21.1	-	-	-
Dissolved Oxygen (D.O.)	2.1	-	-	-	3.5	-	-	-
D.O. % Saturated	23.4	-	-	-	38.6	-	-	-
pH Value	6.5	-	-	-	6.5	-	-	-

Storm	No. 23-2
Date	June 13, 1969 Fri
Sampling Period	6:00 AM-1:00 PM
Sampling Interval	1 Hour

Composite Sample	Influent				Effluent			
	CW& CTL	State	City	Ave.	CW& CTL	State	City	Ave.
Total Solids	490	528	560	526	420	386	414	407
Volatile Solids	184	136	226	182	154	85	169	136
Fixed Solids	306	392	334	344	266	301	245	271
Total Suspended Solids	150	132	158	147	118	120	129	123
Volatile Solids	76	38	75	63	48	30	50	43
Fixed Solids	74	94	83	84	70	90	79	80
Settleable Solids (ml/1)	1.5	1.8	1.6	1.6	0.8	1.1	1.3	1.1
Ether Soluble	31	4.0	32	31.5*	27	6.4	25	26.0*
B.O.D. 5 days @ 20° C	40	57	81	59	20	42	53	38
B.O.D., Settled Sample	40	-	-	-	20	-	-	-
Temperature (°C)	20.1	-	-	-	19.9	-	-	-
Dissolved Oxygen (D.O.)	4.3	-	-	-	5.8	-	-	-
D.O. % Saturated	46.8	-	-	-	63.9	-	-	-
pH Value	6.9	-	-	-	7.0	-	-	-

* Average of CW&CTL and City values

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 23-3
Date	June 13, 1969 Fri
Sampling Period	2:00 PM-9:00 PM
Sampling Interval	1 Hour

Composite Sample	Influent				Effluent			
	CW& CTL	State	City	Ave.	CW& CTL	State	City	Ave.
Total Solids	594	615	667	625	590	653	637	627
Volatile Solids	176	154	223	184	196	179	185	187
Fixed Solids	418	461	444	441	394	474	452	440
Total Suspended Solids	90	62	95	83	66	94	76	79
Volatile Solids	70	40	70	60	54	60	53	56
Fixed Solids	20	22	26	23	12	34	23	23
Settleable Solids (ml/1)	0.9	1.5	1.0	1.1	0.3	0.5	0.3	0.4
Ether Soluble	55	0.8	22	38.5**	86	5.2	8	47.0**
B.O.D. 5 days @ 20° C	120	86	90	99	88	62	75	75
B.O.D., Settled Sample	100	-	-	-	88	-	-	-
Temperature (°C)	21.2	-	-	-	21.1	-	-	-
Dissolved Oxygen (D.O.)	0.9	-	-	-	3.0	-	-	-
D.O. % Saturated	10.3	-	-	-	33.5	-	-	-
pH Value	6.8	-	-	-	6.9	-	-	-

Storm	No. 24-1
Date	June 22, 1969 Sun.
Sampling Period	4:30 PM-11:30 PM
Sampling Interval	1 Hour

Composite Sample	Influent				Effluent			
	CW& CTL	State	City	Ave.	CW& CTL	State	City	Ave.
Total Solids	258	352	356	354*	256	313	332	322*
Volatile Solids	126	94	76	85*	144	82	134	108*
Fixed Solids	132	258	280	269*	112	231	198	214*
Total Suspended Solids	106	80	103	96	68	74	76	73
Volatile Solids	74	22	60	52	42	20	50	37
Fixed Solids	32	58	43	44	26	54	26	36
Settleable Solids (ml/1)	1.3	1.0	0.9	1.1	0.8	0.7	0.4	0.6
Ether Soluble	25	8.4	20	22.5**	20	9.2	12	16 **
B.O.D. 5 days @ 20° C	90	61	59	70	65	57	46	56
B.O.D., Settled Sample	70	-	-	-	25	-	-	-
Temperature (°C)	21.3	-	-	-	21.4	-	-	-
Dissolved Oxygen (D.O.)	0.8	-	-	-	3.0	-	-	-
D.O. % Saturated	8.4	-	-	-	35.1	-	-	-
pH Value	6.3	-	-	-	6.4	-	-	-

*Average of State and City Values

** Average of CW&CTL and City Values

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 24-2
Date	June 23, 1969 Mon
Sampling Period	12:30 AM-7:30 AM
Sampling Interval	1 Hour

Composite Sample	Influent				Effluent			
	CW& CTL	State	City	Ave.	CW& CTL	State	City	Ave.
Total Solids	414	426	488	443	352	366	417	378
Volatile Solids	206	86	118	137	144	80	108	111
Fixed Solids	208	340	370	306	208	286	309	267
Total Suspended Solids	110	210	212	211*	138	146	163	149
Volatile Solids	38	74	74	74*	72	22	56	50
Fixed Solids	72	136	138	137*	66	124	107	99
Settleable Solids (ml/1)	1.6	1.5	1.5	1.5	1.1	1.3	1.0	1.1
Ether Soluble	34	10	41	37.5#	14	72	30	22.0#
B.O.D. 5 days @ 20° C	60	45	49	51	45	30	34	36
B.O.D., Settled Sample	30	-	-	-	20	-	-	-
Temperature (°C)	19.6	-	-	-	19.7	-	-	-
Dissolved Oxygen (D.O.)	5.0	-	-	-	6.1	-	-	-
D.O. % Saturated	53.5	-	-	-	65.4	-	-	-
pH Value	6.6	-	-	-	6.7	-	-	-

Storm	No. 24-3
Date	June 23, 1969 Mon
Sampling Period	8:30 AM-3:30 PM
Sampling Interval	1 Hour

Composite Sample	Influent				Effluent			
	CW& CTL	State	City	Ave.	CW& CTL	State	City	Ave.
Total Solids	582	609	1132	596**	552	567	601	573
Volatile Solids	182	101	786	142**	152	97	229	159
Fixed Solids	400	508	346	454**	400	470	372	414
Total Suspended Solids	96	146	86	109	70	94	74	79
Volatile Solids	62	46	57	55	54	22	46	40
Fixed Solids	34	100	29	54	16	72	28	39
Settleable Solids (ml/1)	1.8	2.0	1.1	1.6	1.3	1.8	1.3	1.5
Ether Soluble	32	7.2	15	23.5#	18	14.8	14	15.5#
B.O.D. 5 days @ 20° C	100	73	55	76	45	63	56	55
B.O.D., Settled Sample	30	-	-	-	45	-	-	-
Temperature (°C)	19.7	-	-	-	19.7	-	-	-
Dissolved Oxygen (D.O.)	4.9	-	-	-	5.9	-	-	-
D.O. % Saturated	53.1	-	-	-	64.3	-	-	-
pH Value	7.2	-	-	-	7.2	-	-	-

* Average of State and City values

** Average of CW&CTL and State values

# Average of CW&CTL and City values

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 24-4
Date	June 23, 1969 Mon
Sampling Period	4:30 PM-11:30 PM
Sampling Interval	1 Hour

Composite Sample	Influent				Effluent			
	CW& CTL	State	City	Ave.	CW& CTL	State	City	Ave.
Total Solids	538	623	665	609	500	583	624	569
Volatile Solids	142	118	318	193	116	105	239	153
Fixed Solids	396	505	347	416	384	478	385	416
Total Suspended Solids	182	236	227	215	172	154	177	168
Volatile Solids	84	50	80	71	60	36	65	54
Fixed Solids	98	186	147	144	112	118	112	114
Settleable Solids (ml/1)	1.9	2.0	1.6	1.8	1.4	1.9	1.4	1.6
Ether Soluble	21	9.6	54	37.5**	17	11.6	32	24.5**
B.O.D. 5 days @ 20° C	60	68	70	66	60	56	60	59
B.O.D., Settled Sample	40	-	-	-	40	-	-	-
Temperature (°C)	21.1	-	-	-	20.9	-	-	-
Dissolved Oxygen (D.O.)	4.6	-	-	-	5.4	-	-	-
D.O. % Saturated	51.2	-	-	-	59.3	-	-	-
pH Value	7.2	-	-	-	7.2	-	-	-

Storm	No. 24-5
Date	June 24, 1969 Tues
Sampling Period	12:30 AM-7:30 AM
Sampling Interval	1 Hour

Composite Sample	Influent				Effluent			
	CW& CTL	State	City	Ave.	CW& CTL	State	City	Ave.
Total Solids	560	578	668	602	572	554	644	590
Volatile Solids	254	116	318	229	260	104	272	212
Fixed Solids	306	462	350	373	310	450	372	378
Total Suspended Solids	18	48	48	48*	12	51	52	51*
Volatile Solids	12	19	32	26*	10	20	34	27*
Fixed Solids	6	29	16	22*	2	31	18	24*
Settleable Solids (ml/1)	0.6	1.0	0.2	0.6	0.4	1.1	0.1	0.5
Ether Soluble	60	10.8	19	39.5**	58	10.4	11	34.5**
B.O.D. 5 days @ 20° C	60	42	45	49	45	32	46	41
B.O.D., Settled Sample	30	-	-	-	25	-	-	-
Temperature (°C)	19.6	-	-	-	19.7	-	-	-
Dissolved Oxygen (D.O.)	4.1	-	-	-	5.3	-	-	-
D.O. % Saturated	44.1	-	-	-	57.2	-	-	-
pH Value	7.1	-	-	-	7.2	-	-	-

* Average of State and City values
** Average of CW&DTL and City values

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 24-7
Date	June 24, 1969 Tues
Sampling Period	4:30 PM-11:30 PM
Sampling Interval	1 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	490	535	513	400	459	430
Volatile Solids	170	110	140	150	94	122
Fixed Solids	320	425	373	250	365	308
Total Suspended Solids	236	178	207	150	162	156
Volatile Solids	88	34	61	44	26	35
Fixed Solids	148	144	146	106	136	121
Settleable Solids (ml/1)	1.5	1.8	1.65	0.9	1.9	1.4
Ether Soluble	8	11.6	8.0*	6	9.6	6.0*
B.O.D. 5 days @ 20° C	30	39	35	30	30	350
B.O.D. on Settled Sample	30	-	-	15	-	-
Temperature (°C)	21.1	-	-	21.1	-	-
Dissolved Oxygen (D.O.)	4.6	-	-	5.7	-	-
D.O. % Saturated	53.8	-	-	63.0	-	-
pH Value	7.2	-	-	7.3	-	-

Storm	No. 24-8
Date	June 25, 1969 Wed.
Samplind Period	12:30 AM-7:30 AM
Sampling Interval	1 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	576	547	562	556	450	503
Volatile Solids	202	98	150	164	180	172
Fixed Solids	374	449	412	392	270	331
Total Suspended Solids	52	38	45	42	47	45
Volatile Solids	26	15	21	18	16	17
Fixed Solids	26	23	24	24	31	28
Settleable Solids (ml/1)	0.5	1.9	1.2	0.3	1.0	0.65
Ether Soluble	85	13.2	85.0*	76	11.2	76.0*
B.O.D. 5 days @ 20° C	30	19	25	15	17	16
B.O.D. on Settled Sample	30	-	-	10	-	-
Temperature (°C)	19.1	-	-	19.1	-	-
Dissolved Oxygen (D.O.)	5.2	-	-	6.2	-	-
D.O. % Saturated	55.2	-	-	66.2	-	-
pH Value	7.4	-	-	7.3	-	-

* CW&CTL Values only

WHITTIER STREET STORM STANDBY TANKS
DATA PERTINENT TO SAMPLING AND RESULTS OF LABORATORY TESTS

Storm	No. 24-9
Date	June 25, 1969 Wed.
Sampling Period	8:30 AM-3:30 PM
Sampling Interval	1 Hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	634	661	648	594	930	594*
Volatile Solids	284	137	211	260	389	260*
Fixed Solids	350	524	437	334	541	334*
Total Suspended Solids	88	118	103	54	80	67
Volatile Solids	78	70	74	48	44	46
Fixed Solids	10	48	29	6	36	21
Settleable Solids (ml/l)	1.9	2.8	2.35	0.4	0.5	0.45
Ether Soluble	82	12.4	82.0*	92	8.0	92.0*
B.O.D. 5 days @ 20° C	130	92	111	85	64	75
B.O.D. on Settled Sample	110	-	-	55	-	-
Temperature (°C)	20.2	-	-	20.2	-	-
Dissolved Oxygen (D.O.)	3.6	-	-	4.6	-	-
D.O. % Saturated	38.9	-	-	50.4	-	-
pH Value	7.3	-	-	7.3	-	-

Storm	No. 24-10
Date	June 25, 1969 Wed.
Sampling Period	4:30 PM-11:30 PM
Sampling Interval	1 hour

Composite Sample	Influent			Effluent		
	CW&CTL	State	Ave.	CW&CTL	State	Ave.
Total Solids	652	709	681	658	679	669
Volatile Solids	254	183	219	252	166	209
Fixed Solids	398	526	462	406	513	460
Total Suspended Solids	134	146	140	82	82	82
Volatile Solids	128	100	114	76	56	66
Fixed Solids	6	46	26	6	26	16
Settleable Solids (ml/l)	1.4	2.5	1.95	0.2	0.8	0.5
Ether Soluble	35	20	35.0*	50	19.6	50.0*
B.O.D. 5 days @ 20° C	150	153	152	170	132	151
B.O.D. on Settled Sample	140	-	-	130	-	-
Temperature (°C)	20.9	-	-	21.0	-	-
Dissolved Oxygen (D.O.)	1.9	-	-	2.7	-	-
D.O. % Saturated	20.9	-	-	30.3	-	-
pH Value	7.2	-	-	7.2	-	-

*CW&CTL Value only

Continued from inside front cover....

11022	---	08/67	Phase I - Feasibility of a Periodic Flushing System for Combined Sewer Cleaning
11023	---	09/67	Demonstrate Feasibility of the Use of Ultrasonic Filtration in Treating the Overflows from Combined and/or Storm Sewers
11020	---	12/67	Problems of Combined Sewer Facilities and Overflows, 1967 (WP-20-11)
11023	---	05/68	Feasibility of a Stabilization-Retention Basin in Lake Erie at Cleveland, Ohio
11031	---	08/68	The Beneficial Use of Storm Water
11030	DNS	01/69	Water Pollution Aspects of Urban Runoff, (WP-20-15)
11020	DIH	06/69	Improved Sealants for Infiltration Control, (WP-20-18)
11020	DES	06/69	Selected Urban Storm Water Runoff Abstracts, (WP-20-21)
11020	---	06/69	Sewer Infiltration Reduction by Zone Pumping, (DAST-9)
11020	EXV	07/69	Strainer/Filter Treatment of Combined Sewer Overflows, (WP-20-16)
11020	DIG	08/69	Polymers for Sewer Flow Control, (WP-20-22)
11023	DPI	08/69	Rapid-Flow Filter for Sewer Overflows
11020	DGZ	10/69	Design of a Combined Sewer Fluidic Regulator, (DAST-13)
11020	EKO	10/69	Combined Sewer Separation Using Pressure Sewers, (ORD-4)
11020	---	10/69	Crazed Resin Filtration of Combined Sewer Overflows, (DAST-4)
11024	FKN	11/69	Stream Pollution and Abatement from Combined Sewer Overflows - Bucyrus, Ohio, (DAST-32)
11020	DWF	12/69	Control of Pollution by Underwater Storage
11000	---	01/70	Storm and Combined Sewer Demonstration Projects - January 1970
11020	FKI	01/70	Dissolved Air Flotation Treatment of Combined Sewer Overflows, (WP-20-17)
11024	DOK	02/70	Proposed Combined Sewer Control by Electrode Potential
11023	FDD	03/70	Rotary Vibratory Fine Screening of Combined Sewer Overflows, (DAST-5)
11024	DMS	05/70	Engineering Investigation of Sewer Overflow Problem - Roanoke, Virginia
11023	EVO	06/70	Microstraining and Disinfection of Combined Sewer Overflows
11024	---	06/70	Combined Sewer Overflow Abatement Technology